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PHLEBOGRAPHY AND VENOUS PRESSURE DETERMINATION

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STELLINGEN

I

Operatieve behandeling van het ulcus cruris dient te worden voorafgegaan door een flebografisch onderzoek.

II

Insufficiëntie van perforerende venen in het onderbeen geeft aanleiding tot ernstige stoornissen in de veneuze pompwerking ook indien geen afwijkingen in de diepe venen van het onderbeen aantoonbaar zijn.

III

Intra-arteriële toediening van kanker chemotherapeutica bij overigens therapie resistente tumoren in het stroomgebied van de arteria carotis externa kan een waardevol palliatief effekt hebben.

IV

De oorzaak van de spontaan optredende stuwingsicterus in de graviditeit is waarschijnlijk in de progesteron stofwisseling gelegen.

V

De opvatting van Hunt en Kuffler dat polyneurale innervatie van spiervezels bij de kat veelvuldig voorkomt is niet houdbaar.

VI

De gewoonte venasecties te verrichten in het onderbeen is onjuist.

VII

Bij het bepalen van het calciumgehalte van het bloed dient steeds het totaal eiwitgehalte mede bepaald te worden.

VIII

De kans op postoperatieve longcomplicaties wordt door het profylactisch geven van antibiotica niet verminderd.

IX

Daar de 'white line' van Hilton geen duidelijk anatomisch substraat heeft, verdient het aanbeveling dit begrip niet langer te bezigen.

X

Het streven van het ministerie van O.K. en W. om het tot stand komen van zeer grote scholen (meer dan 1000 leerlingen) te bevorderen wekt terecht bezorgdheid in onderwijskringen.

PHLEBOGRAPHY
AND VENOUS PRESSURE DETERMINATION

Dit proefschrift werd bewerkt in de Heelkundige Kliniek van het Academisch Ziekenhuis te Leiden

PHLEBOGRAPHY AND VENOUS PRESSURE DETERMINATION

A study into the correlation of the data gained from these methods

PROEFSCHRIFT

TER VERKRIJGING VAN DE GRAAD VAN DOCTOR IN DE GENEESKUNDE AAN DE RIJKSUNIVERSITEIT TE LEIDEN, OP GEZAG VAN DE RECTOR MAGNIFICUS MR J. V. RIJPPERDA WIERDSMA, HOOGLERAAR IN DE FACULTEIT DER RECHTSGELEERDHEID, TEGEN DE BEDENKINGEN VAN DE FACULTEIT DER GENEESKUNDE TE VERDEDIGEN OP WOENSDAG 19 OKTOBER 1960 TE 15 UUR

door

MORTEN NIELS VAN DER HEYDE

geboren te Galéria (Frankrijk) in 1928

H. E. STENFERT KROESE N.V. - LEIDEN

PROMOTOR: PROF. DR M. VINK

CONTENTS

INTRODUCTION 1

I. PHLEBOGRAPHY 3

Value of the method 3

Questions to be answered in phlebography 7

A. Ascending phlebography (8) - *B. Descending phlebography* (8) - *C. Phlebography of the pelvic veins* (8)

Can a phlebogram answer these questions? 8

A. The ascending phlebogram (8) - *B. The descending phlebogram* (10) - *C. The phlebogram of the pelvic veins* (10)

Technique of phlebography 10

A. Ascending phlebography (10) - *B. Descending phlebography* (14) - *C. Pelvic phlebography* (17)

II. VENOUS PRESSURE DETERMINATION 19

Venous hypertension 19

Pumping action of the muscles 21

Impairment of the pumping mechanism 24

Impairment due to incompetence of perforating veins . . 26

Impairment due to changes in the deep veins 29

Differentiation between the various forms of impairment 31

Summary 34

III. PERSONAL INVESTIGATIONS 36

Objective 36

Cases studied 36

Technique 37

Phlebography 37

Ascending phlebography (37) - *Descending phlebography* (40) - *Pelvic veins* (40) - *Comment* (41)

Venous pressure determination 41

Observations during the fall in venous pressure (42) - *Comment* (43)

Complications 44

Classification 45

Results obtained in examination of the various groups 46

CONCLUSION 60
Patients not classifiable with any of the groups 62
Patients in whom the results obtained in clinical and X-ray studies did not correlate whith those obtained in venous pressure determination. 64
Comment (66)
Indications for venous pressure determination and phlebography. 66
Clinical use of venous pressure determination 70
a. Venous pressure determination as an adjunct to phlebography (70) - *b. Venous pressure determination as a substitute for ascending phlebography* (74) - *c. Venous pressure determination as a substitute for descending phlebography* (75)

SUMMARY 76
SAMENVATTING. 81
RÉSUMÉ. 86
REFERENCES 89

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INTRODUCTION

In a particular group of cases, impairment of the venous circulation of the legs gives rise to symptoms. As a rule, taking the history of the patient and making a simple examination will be sufficient to decide whether a case should be classified with this group. The following pathological changes, whether or not associated with one another, may be observed in these cases:

a sense of heaviness or fatigue, occasionally pain, in the leg;
varices, possible recurrent phlebitis;
oedema not found to be due to other causes on physical examination;
pigmentations of the skin;
induration of the subcutaneous tissue;
ulcer of the leg or a scar left by this form of ulcer;
cyanosis of the skin of the foot and leg.

Experience shows that impairment of the venous return usually is present in cases marked by these changes. In the course of time, a causal relationship was naturally established between these conditions. It should be realized, however, that though experience warrants the assumption that there is a relationship of this type, an important link is missing; for it is not known why a particular disturbance of the venous return gives rise to the appearance of the changes observed. None the less, it is believed that efforts should be made to form the most accurate possible opinion on the nature and localization of the circulatory disturbance prior to deciding on any form of treatment in these cases.

In some of these cases, the history and examination will already have supplied sufficient data to decide upon treatment. In a large group of patients, however, this cannot be considered sufficient; not even when examination is completed by the use of diagnostic aids such as the Trendelenburg and Perthes tests.

It will be shown that phlebography is essential in determining the nature of the impairment of the circulation in these cases. This method of examination will provide the most accurate possible data on the nature and localization of the changes in the venous

1

system. As a rule, the findings will enable an opinion on the extent to which the function of this system has been impaired by the changes observed. A more accurate and objective opinion on function, however, can be reached by venous pressure determinations.

When there is a marked correlation between the results obtained in phlebography and those obtained in determination of the venous pressure, this combined examination will probably provide a reliable method of deciding upon the correct indication when some form of therapy is contemplated in patients showing severe impairment of the venous circulation. The present investigation was carried out to determine whether there is a correlation of this type.

Chapter I will be concerned with phlebography. A classification into various groups of the extremities studied will be based on the X-ray findings. Subsequently, venous pressure determination is reviewed in Chapter II and the use of this method in diagnosis is discussed. The results obtained in the study of one hundred extremities will be reported in Chapter III, the findings in venous pressure determination being compared with the results obtained in phlebography. The final section is concerned with the discussion of a number of conclusions believed to be warranted by the results of this investigation.

I. PHLEBOGRAPHY

VALUE OF THE METHOD

About 1930, the development of contrast mediums, the intravascular injection of which does not involve any grave hazards, induced several investigators to study the circulation by X-ray. The first report on the clinical possibilities of this method in studying the venous system was published by C. dos Santos in 1938. During the following years a large number of investigators were concerned with phlebography, particularly in the Scandinavian countries.

This method of investigation afforded a much better insight into the venous circulation both in normal and in pathological conditions. A large number of theories on the circulation in and following venous thrombosis and on the pathogenesis of leg ulcers were verified or disproved. Although phlebography developed into a reliable method of examination in course of time, it has not yet become universally adopted. An operation upon the arterial system will never be performed unless a pre-operative X-ray examination has been made (aorto-arteriography); this is not the practice when the venous system is involved.

The present author tried to find an answer to the question why the use of phlebography meets with resistance in some quarters. The following answers may be given.

1. The examination is not essential to a correct diagnosis.
2. Interpreting a phlebogram is difficult.
3. There are too many misleading factors which might lead to incorrect conclusions.
4. It is a time-consuming procedure which may be more harmful than beneficial to the patient.

The following comments may be made on these hypothetical answers.

Sub 1. The term diagnosis here means defining a disturbance of the circulation as accurately as possible and not determining a

number of changes caused by this disturbance. The two following questions will be discussed on this assumption.

a. Can a sure diagnosis be established without a phlebogram?
b. Is a sure diagnosis essential to guided treatment?

Sub 1a. The question mainly is one of establishing two differential diagnoses, that between primary and post-thrombotic or otherwise symptomatic varices and that between varicose and post-thrombotic leg ulcer.

In a large number of cases, there is no difficulty in establishing a diagnosis of primary varicosis. The diagnosis is more difficult to establish in complicated primary varicosis, particularly when ulceration has resulted.

Will it be possible to reach conclusions regarding the pathogenesis from the appearance of the extremity, i.e., from the presence of certain symptoms accompanying the ulcer? The most important study on the subject was done by Stürup (1950). Summarizing the findings as reported by this author, the following table may be drawn up.

Incidence of oedema and induration in patients with primary varices and those having had thrombosis

	Post-thromb.	Prim. var.
Oedema	83.1 %	43 %
Induration with		
typical localization	74 %	40 %
atypical localization	36 %	17 %
circular localization about the ankle	24 %	7 %

Accordingly, these accessory symptoms apparently are less common in varicose ulcers, though they do occur in these cases. Höjensgaard (1951), having studied 207 extremities, also reached the conclusion that post-thrombotic ulcer of the leg associated with oedema and induration is the more common, but that a differential diagnosis based only on the history and clinical picture will be unreliable.

Therefore, the lower leg syndrome (Dodd and Cockett), as this clinical picture is often called, may be due either to varicosis or to sequelae of thrombosis. The incidence of the symptoms marking this syndrome as reported in the literature varies with the author.

	Oedema	Ulcer	Induration	Pain	Varices
Bauer	100 %	87 %	100 %	100 %	—
Murphy	100 %	87 %	100 %	38 %	100 %
Linton	100 %	43 %	57 %	64 %	94 %
Höjensgaard	83.1 %	100 %	74 %	80 %	78 %
Delannoy, Huriez et al.	49 %	100 %	41 %	84 %	83 %

Homans, in 1946, described a number of markedly varying clinical pictures to which thrombosis may give rise.

1. Oedema unaccompanied by other changes.
2. Pain unconfined to a particular dermatome.
3. Cyanotic discolouration of the skin of the foot and ankle, and dilated veins in this area.
4. Varicosis and recurrent phlebitis.
5. The most important group characterized by pigmentation, subcutaneous fibrosis and possibly ulcers.

Incompetent perforating veins have long been known to occur in primary varices as well as in cases of damage following thrombosis (Homans 1917). Arenander (1956) who did phlebographic studies in 247 patients, observed incompetent perforators in 66 per cent of the patients showing post-thrombotic symptoms and in from 80 to 90 per cent of the patients showing dilated deep veins of the leg which were not post-thrombotic. Several authors claim to be able to localize incompetent perforators by palpation. It is doubtful, however, with all due respect for their sense of touch, whether this will also be practicable in the case of an oedematous, indurated leg showing ulceration. Höjensgaard and Linton use a modified Trendelenburg test in localizing incompetent perforators; it naturally is essential that the superficial veins should be clearly perceptible.

Therefore, physical examination alone usually will not provide sufficient data on which to base a well-founded opinion on the pathogenesis of an ulcer. This is equally true for the exclusion of post-thrombotic changes in the deep veins in a large number of cases. As regards the history: anyone knows that though several patients are able definitely to state that they have had thrombosis, this is positively denied by many others, despite the fact that subsequent examination shows the reverse to be true.

Sub 1b. Accordingly, the method of treatment referred to is one not only designed to correct the secondary changes of which the patient complains, but also directed towards eliminating the impairment of the circulation which was an essential factor in the pathogenesis of these changes.

Naturally, conservative treatment and application of the various types of supporting bandage are practicable without a sure diagnosis. In the opinion of the present author, however, a positive diagnosis will be essential in surgical treatment. Anyone who is familiar with the literature on disturbances of the venous circulation, will be aware of the controversies between the various authors regarding the pathogenesis of leg ulcers. Without entering more fully into this issue, the present author wishes to state as his view that the pre- and postoperative assessment of the condition of the patient frequently is not sufficiently critical owing to this difference of opinion concerning the pathogenesis and the ideal method of treatment.

In the opinion of the present author, ligation of all medial perforators (Dodd and Cockett) is not correct unless they have been shown to be incompetent; nor should a popliteal vein be resected (Bauer) when it is assumed to be incompetent in view of the clinical picture (E. Saarenmaa, 1959). There is no point in extracting varices when these may merely be symptoms of a more severe lesion and extraction may even be injurious to the patient.

The fact that the results as reported in literature, obtained by various surgeons using a similair procedure differ markedly, probably is largely attributable to the fact that the indication for a particular form of therapy is not always identical owing to inadequate diagnosis.

Sub 2. Interpreting a phlebogram requires experience and some knowledge of studies on the subject. The literature constantly provides instances in which features that have been amply shown to appear in the normal phlebogram as well, are put forward as evidence of the presence of a lesion. Fuller reference will be made to this point in the discussion of the technique. Let it suffice here to state that phlebography is a procedure which should be used frequently or not at all.

Sub 3. As a matter of fact, an incorrect technique may involve a number of misleading factors which might result in mistaken

conclusions. Some of these factors will be referred to in discussing the technique.

It is of special importance that the investigator should realize which questions are to be answered in making the examination, in other words, that he should not look to the phlebogram for anything else than an X-ray picture of the anatomical changes present. This subject will also be discussed in greater detail later on.

Sub 4. Phlebography is a time-consuming procedure. It requires about sixty minutes. There is a risk of complications occurring during and after examination. Fuller reference to the subject will be made in Chapter III. These complications will naturally cause some distress to the patient and involve additional loss of time. Experience shows that patients suffering from the sequelae of impairment of the venous circulation tend to regard any form of treatment with scepticism. Laymen frequently believe that lesions such as ulcers of the leg are incurable. When a detailed examination is made, however, and the patient realizes that this examination also requires the spending of plenty of time by the attending physician, this will inspire the confidence essential in subsequent treatment. Everyone will have to decide for himself to what extent he has time available for this examination. If he should not have sufficient time to study the clinical picture shown by a patient with a complicated lesion, he should refer the patient to a centre where this can be done.

Summarizing, it can be stated that for want of other methods ensuring an adequate indication, every surgical procedure involving an extremity marked by severe impairment of the venous circulation should be preceded by phlebography. Therefore, those wishing to perform these operations should make themselves conversant with the technique of this examination.

QUESTIONS TO BE ANSWERED IN PHLEBOGRAPHY

The methods used in phlebography of the lower extremities are ascending phlebography, descending phlebography and phlebography of the pelvic veins. These methods are designed to supply the examiner with answers to the following questions.

A. Ascending phlebography

1. Is the deep venous system morphologically normal?
2. Do the findings suggest that the normal course of events in the venous return is disturbed?
3. Do the findings suggest that the patient has had thrombosis? If the answer is in the affirmative, has recanalization of the deep veins of the leg and thigh occurred?

B. Descending phlebography

Are the common, superficial and deep femoral veins present and normal?

If this is not the case, is a recanalized or collateral deep system present in the thigh?

C. Phlebography of the pelvic veins

Are these normal, obliterated or recanalized, are any collaterals present? Is the iliac vein normally localized or has it been displaced?

CAN A PHLEBOGRAM ANSWER THESE QUESTIONS?

A. The ascending phlebogram

1. Is the deep system morphologically normal?

The normal phlebogram as it appears in patients not showing any impairment of the venous circulation has been described, among others, by Greitz (1956) and Höjensgaard (1951). These authors state that when a correct technique is used, filling of the three important veins of the leg, the popliteal and femoral vein should result in every case.

Valves should be detectable in the veins of the leg. These need not be perceptible in the popliteal and femoral veins. The veins of the leg may be dilated without this being of any importance. Retrograde filling of perforators is not abnormal, no more than that of muscle veins which usually occur in pairs and present a spindle-shaped appearance (cf. Figs. XIII, XIV and XV).

2. As will be explained in the following chapter, what is referred to here is impairment of function of the pumping mechanism of the muscles of the leg. Briefly, the venous pump may be stated only to be functioning optimally when all the blood which has collected in the veins of this region during relaxation of the muscles of the leg is carried proximad during contraction.

The post-thrombotic changes which may result in impairment of this mechanism will be reviewed under 3.

It will be shown that incompetence of perforators also causes impairment of function. In most cases, this disturbance is demonstrable in the ascending phlebogram. When these veins are dilated, follow a tortuous course and are characterized by retrograde filling, they may be assumed to be incompetent. Arenander (1956) and Greitz (1955) describe a U-shaped shadow in these cases in which both the deep and superficial vein are also dilated above their communication with the dilated perforator. Renes (1950) and Höjensgaard (1951) do not regard phlebography as a reliable method by which to demonstrate the presence of perforators. Associated with incompetent perforators, though also unaccompanied by the latter, changes of the deep veins of the leg are occasionally observed, which changes might also give rise to impairment of function: varicose changes of the muscle veins which have lost their elegant spindle-shaped appearance and partial obstruction of the deep main veins, in some cases with collaterals following a tortuous course and not showing any valves (Greitz 1955) (Cf. Figs. XI and XII).

3. About the most important question is whether or not the deep venous system has been damaged by thrombosis. Post-thrombotic changes are observed in the deep main veins and muscle veins of the leg and thigh. Tortuous, dilated veins without identifiable valves and occasionally showing a completely abnormal localization are evidence of post-thrombotic lesions. This also is the case with abnormal, distended communications between dilated muscle veins and superficial veins when the greater part of the deep system has been obliterated. Failure of the popliteal and femoral veins to be filled with the contrast medium, possibly associated with evidence of recanalization or an identifiable collateral circulation, may also be positively attributed to the fact that the patient has had thrombosis. When the form and localization of the femoral vein are normal, it cannot be concluded that this vein is incompe ent when it does not show any valves in the ascending phlebogram (Bauer 1940, Greitz 1955, Höjensgaard 1951, Löfstedt 1946, Arenander 1956).

B. The descending phlebogram.

When there is a retrograde, distalward flow of contrast fluid through the femoral vein in the descending phlebogram, the contrast medium will accumulate above the valses, if present, when a correct technique is used.

The absence of valves is regarded as evidence of the presence of post-thrombotic changes in the veins of the thigh, except in the few cases in which the valves are congenitally absent. In several cases, the obliteration caused by thrombosis was not followed by appreciable recanalization. In that case, the contrast medium is seen to flow distalward through tortuous, markedly distended, valveless collaterals.

C. The phlebogram of the pelvic veins

When the iliac vein is sufficiently filled with contrast fluid, the course followed by this vein usually can be readily identified as far as the vena cava. In the event of obliteration, a large number of collaterals will be filled and as a rule even the contralateral iliac vein is filled. A recanalized iliac vein is small in diameter and usually shows an irregular outline.

Valves were never observed in the iliac vein, not even when it was normal.

TECHNIQUE OF PHLEBOGRAPHY

A correct technique is essential in obtaining a readily interpretable, reliable X-ray picture of the venous system (cf. Figs. I and II). Therefore, fuller reference will be made to a number of points in discussing the technique of the three methods used.

A. Ascending phlebography

When this procedure is adopted, a contrast medium is injected by intravenous route distal to the veins to be examined and then carried along by the venous blood stream.

1. Position of the patient.
2. Site of injection of the contrast medium.
3. Application of tourniquets.
4. Bandaging of the leg.
5. The contrast medium.
6. The method used in making the exposures.
7. Artifices used to facilitate interpretation of the phlebogram.

Sub A 1. The recumbent position naturally will be the most comfortable for the patient during examination. Accordingly, a number of authors perform phlebography with the patient lying down (C. dos Santos 1938, Bauer 1942, Mahorner 1943, Massell et al. 1948).

Various authors have raised objections against this posture for different reasons. Hellsten (1942), comparing the phlebograms made in the standing and recumbent positions, observed better filling of the deep veins in the standing position. Kjellberg (1943) pointed out that sedimentation of the contrast medium, the specific gravity of which is higher than that of the blood, occurs in the veins of the recumbent patient. Löfstedt and Linde did a comparative study (1946). These authors also draw attention to sedimentation which may result in confusing phlebograms. Another drawback pointed out by Löfstedt and Linde consists in the stepwise descent of the contrast medium in veins which do not play an important rôle in the actual circulation, though the contrast medium collects in these veins by gravity. Frimann-Dahl (1947) drew attention to the risk of compression of deep veins in a recumbent patient with heavy calf muscles. Greitz (1954) who did a comparative study found filling of the popliteal and other deep veins to be inferior in the recumbent position. He pointed out that confusing phlebograms may result from the formation of layers by the blood and contrast medium. With those previously cited, several other authors prefer the vertical position.

It should also be pointed out that Greitz did not observe any difference between phlebograms made in patients in the vertical position and those made in patients in a position of 65 degrees anti-Trendelenburg.

Sub A 2. Site of injection of the contrast medium.
In the opinion of the present author, there is little sense in making an X-ray examination following injection of a contrast medium into a random varix, as the drawing of conclusions from the phlebograms obtained will only be warranted in exceptional cases. This method was frequently used about 1935 to determine the direction of the flow in varices.

Dos Santos and Bauer, followed by several others (e.g., de Reus, 1957), injected the contrast medium into the short saphenous

vein at a point behind the lateral malleolus, injecting distalward if necessary. Others (Löfstedt 1946, Greitz 1954) prefer making an injection into a vein of the foot. They showed that this results in more adequate filling of the deep veins of the distal portion of the leg. The more distalward the injection, the better the blood and contrast medium will mix.

In obtaining an optimum phlebogram, it naturally is of little importance whether the contrast medium is injected by direct puncture of a vein or following venesection. The chief objection to venesection is the risk of infection of the wound. This is undoubtedly a considerable hazard in venesection behind the lateral malleolus, in which area the skin frequently shows trophic disturbances. Owing to the poor quality of the veins on the upper surface of the foot or the presence of oedema, venesection will frequently be indicated. In addition, venipuncture in the foot may give rise to collapse in the standing patient.

Sub A 3. Application of a tourniquet about the ankle.
This forces the contrast medium injected distal to the tourniquet into the deep veins. This method is recommended by authors such as Bauer (1942), Greitz (1954) and Mahorner (1943). These authors report better filling of the deep veins and less superficial varices filled with contrast fluid and therefore causing confusion. Moreover, this method will enable a more satisfactory diagnosis of incompetent perforators. Helsten (1942) and Höjensgaard (1951) advise applying a tourniquet below the knee so as to force the contrast medium into the popliteal vein.

Sub A 4. Application of a bandage about the leg.
This is designed to prevent the loss of contrast medium in superficial varices. This increases the difficulty of interpreting the phlebogram and makes it less simple to determine the direction from which the perforators are filled.

Sub A 5. The various types of contrast medium suited for this purpose will not be discussed in further detail. It should be pointed out, however, that the current contrast mediums, the specific gravity of which is higher than that of blood and which do not readily mix with the latter, are anything but ideal.

In addition, it was recently shown by Zinner and Gottlob (1959)

that these substances undoubtedly may have an injurious effect on the wall of the vessels.

Sub A 6. The method used in making the exposures.
Most authors make exposures in the antero-posterior and lateral directions. It frequently is not possible to interpret the antero-posterior X-ray alone. Comparing X-rays taken in two directions, however, was also found to be disappointing. Only a few authors (Fell 1955, de Reus 1957, Moreaux et al. 1959) refer to the stereoscopic method of phlebography.

The rate at which the contrast medium flows proximalwards varies markedly with the patient. Therefore, the making of exposures according to a fixed schedule may result in phlebograms which fail to give a correct impresssion of the actual anatomical condition. Exposures made during fluoroscopy do not have this drawback. Another advantage of fluoroscopy is that it enables the study of the flow of the contrast medium during examination, so that, for instance, a retrograde flow may be identified in perforators.

Sub A 7. In patients with severe impairment of the venous circulation, the contrast medium injected, the specific gravity of which, as stated previously, is higher than that of blood, frequently will stagnate in markedly distended veins on the upper surface of the foot and in the ankle. In that case, the contrast medium in the veins of the leg, not to mention that in the veins of the thigh, will be diluted to an extent preventing any interpretation of the phlebogram.

Manual compression of the foot and ankle causes the contrast medium to flow away in a higher concentration. A more physiological method is to order the patient to perform a few rapid movements with the foot. This method is recommended by Lindblom (1947), Löfstedt (1946) and Greitz (1954), primarily because this enables a better examination of the veins of the thigh, but particularly for the following reason. In a standing patient, there is no difference in pressure between the deep and superficial veins; accordingly, valves possible present in perforators will not affect the direction of the flow. The perforators will usually show retrograde filling by gravity; retrograde as, in static conditions, the flow of blood may be assumed to be directed from the superficial

towards the deep veins. When the muscles of the leg contract, however, a quantity of blood and contrast medium will flow through the perforators to the superficial veins, at any rate when there are no valves to prevent this from happening. This provides a more reliable method by which to determine the presence of incompetent perforators. Dohn (1958) devised another technique ensuring a more readily interpretable phlebogram by suddenly changing the pressure in the veins of the leg, viz., tilt phlebography, in which the contrast medium is injected with the patient lying down; when the deep veins are filled, the patient is suddenly placed in the erect position. Dohn considers this a useful method, mainly as he believes it will enable a more effective determination of the degree of competence of the venous valves in the leg. Mathiesen (1958) used this technique to visualize incompetent perforators and obtained satisfactory results using this method.

Shumacker et al. (1954) developed the adjunct consisting in having the patient perform movements of the foot into a new method of examination, viz., functional venography. This method will be discussed later on.

B. Descending phlebography

When this procedure is used, the contrast medium is injected into the femoral vein near the inguinal region with a view to obtaining a phlebogram of the veins of the thigh by reflux of the contrast medium in these veins.

1. Position of the patient.
2. Method used in injecting the contrast medium.
3. Having the patient strain down.

Sub B 1. In the opinion of the present author, the position of the patient will also be of importance in descending phlebography. As the contrast medium is likely to be very rapidly eliminated in the recumbent position, it is advisable to make this examination in the standing position as well. This also is the more obvious method, as descending phlebography is effected by retrograde filling of the veins of the thigh.

Sub B 2. The method used injecting the contrast medium.
This may be done again either by direct puncture or by venesection. Martinet (1954) and Gullmo (1956) use the method of

direct puncture. Though the number of cases reported shows that they have gained considerable experience, it apparently happens fairly often that the puncture fails (Martinet, 8.6 per cent of the cases). This is not surprising, as experience has shown that the femoral vein sometimes is completely obliterated in patients who have had thrombosis. Several others introduce a polythene catheter into the femoral vein following venesection of the long saphenous vein.

Sub B 3. Having the patient strain down.

Fell (1955) showed that when a contrast medium is injected into the femoral vein, it will flow distalwards against the blood flow by the force of gravity, provided the patient is standing. As a rule, the contrast medium was not found to flow beyond a point half-way the thigh, though it flowed as far as the leg in a few cases. The valves of the femoral and popliteal veins are not closed in static conditions. Therefore, contrast medium flowing past these valves in a retrograde direction, will not accumulate above the valves. Accordingly, a retrograde phlebogram of the femoral vein in which no valves are perceptible may be obtained regardless of the presence or absence of valves in this vein.

This fact was not taken into account by several examiners basing their indications on the findings resulting from retrograde phlebography. Shumacker, Moore and Campbell (1954), however, regarded this fact as evidence of the uselessness of retrograde phlebography and developed a new method of examining the femoral vein. This led to 'functional venography'. Initially, an ascending phlebogram is made, various methods being used to fill the deep veins; as a rule, however, the femoral vein is filled through the popliteal vein. The patient then performs a number of movements with the foot. An opinion of the condition of the femoral vein is based on the exposures made shortly after these movements. When the femoral vein is found to have emptied, it is assumed to play an essential rôle in the circulation.

Phlebography thereby has entered a new field: that of helping to form an opinion on the *function* of a portion of the venous system. This subject will be referred to again later on.

Meanwhile, the rejection of retrograde phlebography has not been universally accepted; on the contrary, this method continues

to be regarded by most authors as essential in forming an opinion on the venous circulation. This lack of agreement is attributable to the following facts.

To begin with, it is necessary to differentiate between a static and a dynamic descending phlebogram. The absence of valves in the femoral vein can never be positively established in the static descending phlebogram in which the examiner is confronted with the situation previously described. The dynamic descending phlebogram, on the other hand, represents the situation occurring when the patient increases the intra-abdominal pressure by straining down (cf. Fig. XVI). This gives rise to the reflux of blood and contrast medium to and within the veins of the thigh. This reflux results in closure of the valves, if any, and contrast medium will accumulate above these valves (Luke 1951, Martinet 1954). When valves are absent, either congenitally (Luke 1941) or as the result of destruction due to thrombosis (Edwards and Edwards 1937), the contrast medium therefore will flow distalwards without encountering any valves (cf. Fig. XIX).

Accordingly, only a dynamic phlebogram, made while the patient increases the intra-abdominal pressure, will be useful in excluding the presence of valves in the femoral vein.

It should be pointed out that other methods have also been suggested for closing the valves of the femoral vein during examination. To begin with, forceful injection of the contrast medium into the femoral vein (Olivier 1950), secondly compression of the iliac vein (Saarenmaa 1959). In the opinion of the present author, it is doubtful whether these methods can actually be used to increase the pressure proximal to the valves to such an extent that they will close.

There is another reason why the use of descending phlebography is considered doubtful. A large number of authors (inter al., Martinet 1954, Gullmo 1956, Shumacker 1949) observed that the contrast medium occasionally passes closed valves in descending phlebography. From this finding it was concluded that these valves were incompetent. As this also occurs, however, in patients with normal femoral veins, the value of the descending phlebogram is disputed in view of this fact (inter al., by Shumacker et al.).

Without entering into an argument regarding the competence of the valves shown to be present by this method, the following

should be stressed at this point. *When the objective of descending phlebography is confined to determining whether or not an anatomically normal (and consequently not a satisfactorily functioning) femoral vein is present, the dynamic descending phlebogram will answer the purpose completely.* The presence of valves suggests that the vein in question has not been severely damaged by thrombosis. In the opinion of the present author, any opinion on the competence of valves based on tilting phlebography, functional phlebography or a descending phlebogram will be of doubtful value.

C. Pelvic phlebography

In this form of phlebography, the contrast medium is injected into the common femoral vein, the method employed being similar to that used in descending phlebography. The patient should not strain down, as this will produce too marked a reflux in the branches of the femoral and external iliac veins. This would create the false impression that there is a collateral circulation in this region.

To ensure satisfactory filling of the caval vein, the contrast medium should be rapidly injected through polythene catheters pushed up as far as the iliac vein on each side.

Summarizing the above, it can be stated that using a correct technique in which the points discussed are taken into account, an answer can be obtained to the following questions.

Is the deep venous system of the leg normally patent or partially obliterated? If patent, do the veins present a normal appearance, do they show a normal localization and are valves perceptible in the veins, so that thrombosis can be assumed not to have occurred in this region? If obliteration should have occurred, is there any evidence of recanalization or the presence of a collateral circulation, associated with varicose changes, an abnormal localization and a valveless state of the main and muscle veins? Are there incompetent perforators or incompetent communications between muscle veins having undergone varicose changes and the superficial venous system? Do the popliteal and femoral veins present a normal appearance and are they provided with valves? If the answer is in the negative, then are they totally or partially obliterated and if this is so, is there any evidence of recanalization or the presence

of a collateral circulation? Is there retrograde filling of the saphenous veins?

Obviously, descending phlebograms will frequently have to be made to enable a complete opinion on the condition of the popliteal vein and the veins of the thigh. This is not essential to forming an opinion on the veins of the leg. Even when valves are clearly identifiable in the veins of the thigh in an ascending phlebogram, retrograde phlebography will not be necessary.

Though attention might, for instance, be paid to the rate at which the veins of the leg empty following contraction of the calf muscles in ascending phlebography, conclusions regarding the function of the veins visualized should not be drawn from the results obtained in phlebography. For one thing, because the fact that the contrast medium is found to stagnate in a particular region does not tell anything about the extent to which the venous system is functioning as a whole, and for another because, taking into account the specific gravity of the contrast medium, it should be realized that stagnation of the blood cannot be positively assumed to occur in a particular region in view of the fact that the contrast medium has been left behind in this region.

Nor is it useful to study the function of identified valves by tilting venography. The only object is to detect the presence of valves.

The technique adopted by the present author will be described in Chapter III. Taking into account the results obtained in phlebography, the patients (extremities) were classified into a number of groups which will subsequently be defined in greater detail. The present study was designed to determine whether there is a correlation between the changes observed on physical examination and phlebography on the one hand and the results obtained in studying the function of the venous system on the other. Determination of the venous pressure was used in forming an opinion on the function of the venous system.

II. VENOUS PRESSURE DETERMINATION

The term venous incompetence was employed a few times previously. This term serves to indicate that condition in which the function of the venous system has been impaired from some cause or other.

The function of the venous system is to ensure an adequate return flow of the blood supplied by the arteries. In this case, adequate means in such a way as to prevent a rise in pressure in the venous portion of the capillary bed. In the capillaries, an equilibrium should be maintained between the forces controlling the circulation of tissue fluid (filtration and counter-filtration pressure). This makes particular demands on the venous system of the legs. It will be shown that the venous pressure in the feet and legs is high in the erect position. When the legs are at rest in the erect position, this pressure will be so high, even in extremities showing an entirely normal venous system, that the balance between the venous pressure on the one hand and the tissue tension and osmotic pressure of the venous blood on the other is upset.

The venous system of the legs is now required to exert an action that will reduce the peripheral venous pressure to a lower level.

Accordingly, the function of the venous system may be considered impaired when this system is not capable of producing the necessary fall in pressure.

VENOUS HYPERTENSION

Of the venous blood from the foot and leg, ninety per cent flows proximalwards through the popliteal and femoral veins and ten per cent flows through the long saphenous vein. In the normal individual in a *recumbent* position, this return flow occurs under conditions and is controlled by factors similar to those governing the flow from any other part of the body. In the recumbent position, the venous circulation will also be satisfactory in patients showing varices or more severe, possibly post-thrombotic changes; stasis of the venous blood flow was never observed in recumbent patients affected with these conditions. On the other hand, the foot-groin

circulation time was found to have increased in these cases in comparison with that in normal subjects (Anlyan 1958). Though theoretically this retardation of the venous blood flow might be attributed to an increased resistance on this route due to the obliteration of important draining veins, this is not likely to be the case. Stanton et al. (1949) found that compression of an extremity results in uniform constriction of the entire venous system, including both the deep and superficial veins. Various methods were used to show that this compression causes a decrease in the foot-groin circulation time. These findings were verified by Zankel et al. (1956). Therefore, the present author believes the retardation of the flow of venous blood in patients showing post-thrombotic changes to be due to enlargement of the venous system. For normally the blood is drained through two veins, whereas in these cases it flows through a large number of often markedly dilated collaterals.

In the normal indivual in the *erect* position, the venous return is competent to the extent that a sufficient quantity of blood is drained per time unit. For it is a fact that stasis of venous blood has never been shown to occur in the lower extremities of normal subjects. Though the rate of flow will have diminished in these conditions, this does not result in a gradual increase in peripheral venous pressure. The regulating mechanisms which normally control the venous blood flow, of which mechanisms the residual arterial pressure is the most important, therefore apparently are also able to maintain this flow in the erect position.

In the erect position, the pressure in the veins of the feet of patients with varices and post-thrombotic disturbances is not any higher than it is in normal individuals. Even prolonged standing does not give rise to increased pressure in these cases (DeCamp et al., 1944). Therefore apparently there is no stasis but an adequate circulation. The flow rate, however, is lower than it is in the normal individual. This may possibly be explained as follows.

When the body is placed in the upright position, the venous pressure in the lower extremities increases within a few seconds to a level approximately equal to the pressure exerted by a column of blood extending from the point of measurement to the heart (Youman et al., 1934). Litter and Wood (1954) showed that the diameter of a vein increases with the intravascular pressure.

Accordingly, any increase in peripheral venous pressure will result in enlargement of the common diameter of the entire venous system between the foot and groin; this will retard the circulation in this region.

Therefore, patients with post-thrombotic extremities are characterized by a retarded flow rather than by venous stasis.

The increased pressure results in a disproportion between the filtration pressure (= venous pressure) in the capillary region and the counter-filtration pressure (= osmotic pressure of the venous blood + tissue tension). Well et al. (1938) showed that this will also give rise to an increase in tissue tension in *normal* individuals following prolonged standing; when the individual had been standing for some time, the feet and ankles were found to have become enlarged. Anning observed oedema of the ankles in soldiers leaning over the railings of troop-ships for hours on end.

PUMPING ACTION OF THE MUSCLES

In addition to the set of mechanisms which keep the normal circulation going, there obviously should be another mechanism, the function of which is to ensure that the peripheral venous pressure in the legs is lowered in the standing individual. This mechanism is the pumping action of the muscles of the leg. The investigations carried out by Beecher, Field and Krogh (1936) and by Seiro (1938) have shown that activity of the leg muscles is associated with a fall in peripheral venous pressure.

As the muscles of the leg will only be completely at rest in exceptional cases in individuals in the erect position, this 'venous pump' will almost constantly be in action. Therefore, venous blood will be removed so regularly by this pumping action that the persistent, injurious venous hypertension will only be present in very rare cases.

Impairment of this mechanism may be due to one of two causes.

1. *Arterial blood is supplied so rapidly that the venous pump cannot ensure its return within a sufficiently short time.*

Henry and Bauer (1950) showed that this phenomenon may actually occur. They increased the arterial flow in the feet by raising the temperature of the skin to 39° C. A demonstrably

increased oxygenation of the venous blood was regarded as evidence of an increased flow. They then found that when these subjects were standing, the venous pressure was markedly higher when movements were performed with the feet than it was in patients in whom the skin temperature was lowered.

Edwards (1954) observed an increase in the 'walking venous pressure' in patients treated with sympathetic block. This increase did not occur when the dorsal artery of the foot was ligated.

Schneewind (1955), however, frequently observed a more rapid decrease in venous pressure following sympathectomy.

2. *The action of the venous pump itself has been impaired.*

a. as the result of insufficient power of the muscles involved in and necessary for this action;
b. as the result of pathological changes in the veins involved.

Sub a. To the knowledge of the present author, there is no literature on observations regarding the venous pressure in patients showing changes in the leg muscles that are so severe that they might give rise to marked impairment of the pumping action of the muscles. Attention should, however, be drawn to the fact that venous changes are frequently observed in cases of poliomyelitis as well as to the fact that oedema of the ankle and leg often persists for prolonged periods in patients with fractures of the leg who have been treated with long-continued immobilization. This form of oedema is termed post-traumatic oedema. In the opinion of the present author, this oedema is attributable at least in part to impairment of the pumping action due to muscular atrophy.

The case of a woman showing an impairment of function of this type will be reported in Chapter III.

Sub b. Which veins are involved in the venous pump and to which extent are they involved?

Contraction of the leg muscles results in a considerable increase in pressure. Well et al., (1938) recorded pressure levels of 118 cm. of water. The venous blood which has accumulated in the veins of these muscles is expressed from these veins. When valves are present in the muscle veins, it can flow in only one direction, viz., towards the deep veins of the leg. The pressure in these veins also increases (Stürup and Höjensgaard, 1952). Then as a result of the

presence of valves in these veins, the blood is propelled into the popliteal and femoral veins. The relaxation following contraction causes a fall in pressure (Stürup and Höjensgaard), so that blood is drawn from the superficial veins through the perforators. The reflux of blood to the veins of the leg from the popliteal and femoral veins is prevented by the presence of valves.

The presence of valves in perforators prevents the blood in the deep veins of the leg and in the muscle veins from flowing towards the superficial system during contraction of the muscles.

Accordingly, adequate function of the venous pump will depend upon a satisfactory condition of the following veins.

The muscle veins and main veins of the leg. For if these veins should permit an opposite direction of the flow as the result of varicose or other, possibly post-thrombotic changes, the physiological return of the blood would be impaired.

The popliteal and femoral veins. For when the calf muscles are relaxed, the valves present in these veins should prevent reflux of the blood removed by the pumping action of the muscles.

The perforating veins. For the valves present in these veins prevent the blood from flowing from the deep to the superficial system during contraction of the calf muscles. It is true that the absence of valves does not prevent the drainage of blood from the superficial veins, but this will be pointless if the blood flows back rapidly again during contraction.

The superficial veins. For when the trunks of the long or short saphenous vein are incompetent, drainage of the distal portion through the perforators will result in a brief retrograde flow. This will in part counteract the drainage of these veins through the deep system.

Therefore, various changes in the venous system may, at least in theory, result in an impairment of function of the venous pump.

An impairment of the action of the venous pump as a whole will manifest itself in a region where this mechanism produces a fall in venous pressure.

A specific region of this type is provided by the distal veins of the upper surface of the foot, which mainly empty through the two saphenous veins, though they also do so through the tibial and peroneal veins (Fransen, 1919).

The venous pressure as determined in a distal vein of the foot after the

patient has performed walking movements therefore is a measure of the function of the venous pump.

Venous pressure determination becomes a useful diagnostic aid when the various factors which may have caused a known disturbance can be separated and therefore differentiated.

IMPAIRMENT OF THE PUMPING MECHANISM

The first important studies on the subject were done by Seiro (1938). Seiro observed that the venous pressure in the distal portion of a long saphenous vein having undergone varicose changes, as determined in a patient in the erect position, was identical with the pressure in normal individuals, but that the fall in pressure caused by walking movements performed by these patients was much smaller than it was in normal individuals. Compression of an incompetent saphenous vein proximal to the site of measurement considerably increased the fall in pressure.

These findings were subsequently verified by a number of other investigators.

	Decrease without compression	*Decrease following compression*
Warren, White, Beecher	26.6 cm. H_2O	57.2 cm. H_2O
Höjensgaard, Stürup	no decrease	65.8 cm. H_2O
Dohn	7 %	80 %

The decrease reported by these authors as occurring after compression of an incompetent long saphenous vein is approximately equal to the fall in pressure as determined by a number of investigators in normal subjects.

		Assuming the average heart level to be 120 cm., the decrease would be:
DeCamp, Ochsner et al.	66.4 %	66.4 %
Warren, White and Beecher	51.7 cm. H_2O	45 %
Walker and Longland	27—40 cm. H_2O	77—70 %
Stürup and Höjensgaard	60 cm. H_2O	50 %
DeCamp and Witz	50—90 %	50—90 %
Dohn	75 %	75 %
Pollack and Tailor	87 cm. H_2O	72 %
Eysholdt	60—90 cm. H_2O	50—90 %

Accordingly, correction of the adverse effect of incompetence of the saphenous vein on the action of the venous pump will completely restore this action: the superficial system of the leg is drained and this results in a fall in pressure which is no longer offset by a refill from the varicose saphenous vein.

It also was Seiro (1938) who found that the venous pressure showed little if any decrease in a number of cases despite compression of the varicose saphenous vein proximal to the site of measurement. This was attributed to incompetent perforators. This finding was not verified by Höjensgaard and Stürup (1950). These authors did observe a marked decrease, viz., by 64 cm. H_2O on compression of the saphenous vein in cases in which incompetent perforators were associated with an incompetent saphenous vein. This probably was due to the fact that these authors determined the pressure in the saphenous vein which usually does not communicate directly with the perforating veins (personal verbal interview with Höjensgaard, 1960).

In 1944, DeCamp, Ochsner et al. reported a number of data on the venous pressure as determined in patients known to have had deep thrombophlebitis. As stated previously, the pressure was not found to be increased in the recumbent or erect positions. The average pressure levels were found to be 16.8 and 7.0 cm. respectively above the heart level in normal individuals and 18.7 and 7.3 cm. above this level in patients showing a post-thrombotic syndrome. After walking, however, there was a very marked difference, viz., the pressure decreased by 66.4 per cent in normal legs and by 38 per cent in post-thrombotic legs. This difference of fall in pressure was subsequently verified by a number of other investigators:

DeCamp and Witz	38 %
Pollack, Tailor et al.	15.7 cm. H_2O
Warren, White and Beecher	10 cm. H_2O
Höjensgaard and Stürup	no decrease
Dohn	1 %
Walker and Longland	no decrease
Schneewind	7 cm. H_2O

These values differ markedly. This probably is due in part to the fact that the methods used in determining the pressure were not identical in every case.

Compression of the saphenous vein had hardly any effect on this disturbance and even resulted in aggravation of the latter.

Fall in pressure following compression of the long saphenous vein in post-thrombotic legs

Dohn	2 % increase
Warren, White and Beecher	unchanged
Höjensgaard and Stürup	unchanged in most cases, the pressure decreasing by 31 cm. H_2O in some cases. This difference could not be accounted for.
Schneewind	16 cm. H_2O.

Summarizing, it can be concluded that there are a number of disturbances of the action of the venous pump, which are attributable to changes in the venous system.

These disturbances may be subdivided into those which can and those which cannot be corrected by compression of the long saphenous vein.

The impairment occurring in primary varicosis unaccompanied by incompetent perforators can be corrected.

The impairment of drainage of the veins of the leg resulting from incompetence of perforators and that following thrombosis apparently cannot be corrected.

IMPAIRMENT DUE TO INCOMPETENCE OF PERFORATING VEINS

The latter is of some importance in regard to the value of venous pressure determination from the point of view of diagnosis. When this examination shows that the venous pressure will decrease normally following compression of the saphenous vein, this is evidence of an adequate function of the deep system. As stated previously, a detailed examination of the patient will only be indicated in exceptional cases of solitary incompetence of a saphenous vein. Severe complications such as oedema, induration and ulcer of the leg hardly ever occur in this condition.

Experience shows that these changes are most common in:

1. incompetence of perforators,
2. changes, usually post-thrombotic, in the deep veins.

The studies by others previously cited showed that it is precisely in these conditions that the venous pressure does not decrease or does so only to a small extent during walking, this also being the case when compression is applied to the saphenous vein.

This might warrant the following conclusion:

1. the fact that the pressure fails to decrease in post-thrombotic legs is due to incompetent perforators,
2. the pathogenesis of oedema, induration and ulcers in post-thrombotic legs is similar to that of varicose ulcers, viz., incompetence of perforators.

This might cause difficulties, as identification of incompetent perforators undoubtedly is not the rule in phlebographic studies on post-thrombotic extremities. From this it should follow that phlebography is seriously deficient in this regard.

In order to verify the theory that perforators are an important factor in the pathogenesis of post-thrombotic disturbances, the following questions should be answered.

I. Is the impairment of function of the venous pump in incompetence of perforators, occurring in an extremity, the deep system of which has not been damaged by thrombosis, permanent or can it it be corrected by methods similar to those used in incompetence of the saphenous vein?

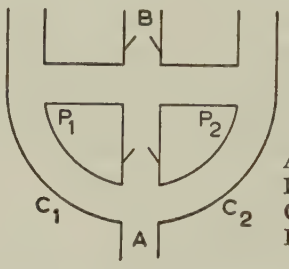
II. If this is so, then can this impairment also be corrected when the deep veins of the leg and thigh show marked post-thrombotic or other changes as well?

Sub I. This question will be answered in the following chapter with the aid of results obtained in the examination of a number of patients. Attempts will be made to give a theoretical answer here. Let us consider the figure on page 28.

The blood from the foot vein A will be drawn proximalwards by the action of the venous pump on the deep vein B, the blood being drawn partially through B and partially through the superficial veins C_1 and C_2 and then also flowing to B through the perforators P_1 and P_2. This will result in a fall in pressure in C_1 and C_2.

When P_1 is an *incompetent* perforator, the fall in pressure occurring during relaxation of the calf muscles will be neutralized again

during the next contraction. For part of the blood in B then will be forced back into C_1. Accordingly, the pressure in C_1 and therefore the pressure in vein A which communicates directly with C_1, though decreasing momentarily, will immediately rise again. Though every step is accompanied by marked variations in pressure (also observed by Seiro), the total decrease therefore will merely be slight. When C_1 and C_2, however, are compressed below P_1 and P_2, so that these vessels can no longer freely communicate with A, the increase in pressure in C_1 will not be transmitted to A. Accordingly, A will be able freely to benefit by the intermittent fall in pressure occurring in B. The pressure in A will then gradually decrease.



A Vein of foot;
B Deep vein of leg;
$C_{1,2}$ Superficial veins of calf;
$P_{1,2}$ Perforators.

This course of events may be reproduced in the examination o patients with the aid of the following method.

The venous pressure is determined in a distally situated vein of the foot. A tourniquet is applied as low as possible about the ankle, in any case below any ulcer that may be present. The patient then performs walking movements. It will be apparent from the description of a number of studies done with the aid of this method that the venous pressure will actually fall to normal levels after walking in certain patients. The patients in question are those in whom phlebography shows that the deep venous system is anatomically normal.

Sub II. Which are the findings in patients showing changes in the deep veins identifiable by X-ray?

As was shown by a number of investigators, the venous pressure does not decrease in these patients when they perform walking movements. Personal investigations showed that the pressure also fails to fall after a tourniquet has been applied about the ankle. Therefore, the impairment of function of the venous pump appar-

ently is much more essential in these cases and cannot be corrected by any of the methods available.

Accordingly, the condition associated with impairment of the action of the venous pump to the extent that there is only a slight fall in walking venous pressure despite compression of the long saphenous vein below the knee, may be due to one of two entirely different changes:

A. incompetent perforators,
B. a more essential disturbance requiring closer examination.

IMPAIRMENT DUE TO CHANGES IN THE DEEP VEINS

When the figure on page 28 is considered, the obvious conclusion is that the latter form of impairment consists in the inability of the pumping mechanism to effect a transient fall in pressure enabling the intermittent withdrawal of blood from A, C_1 and C_2.

Theoretically, this may be due to various causes.

1. The drainage of blood from the deep vessels of the leg during contraction of the calf muscles, is so slight that the fall in pressure occurring on relaxation cannot be measured.
2. Though the leg partially empties during contraction of the calf muscles, relaxation is followed by very rapid filling of the veins. As a result, the pressure during relaxation is not sufficiently low to enable the withdrawal of blood from the foot and the superficial veins of the calf.

Which are the vessels from which this unduly rapid filling might originate?

a. From the arterial system, when there is an abnormally high arterio-venous flow. For studies on the subject, the reader is referred to the writings by Henry and Gauer (1950) and Edwards (1940) cited previously.
b. From varicose muscle veins which fail to empty to a sufficient extent on contraction. The absence of valves and possible changes in the direction of the flow might play a rôle in this case (Höjensgaard, 1951).
c. By retrograde filling from the veins of the thigh.

Sub 1. In theory, drainage of the veins of the leg during contraction of the calf muscles should be inadequate in cases of obstruction of

the proximal venous system, despite the increase in pressure normally occurring when these muscles are contracted.

When the draining veins cannot cope with the venous flow that has been increased by the pumping action, the pressure will show a marked increase during contraction. This occurs in the few cases in which the collateral circulation is inadequate in the event of thrombotic obstruction of the popliteal and femoral veins.

Sub 2 b. Conceivably, varicose changes in the muscle veins of the leg associated with destruction or incompetence of the valves may result in diminished emptying of the veins during contraction of the muscles. This will reduce the fall in pressure on relaxation. Dohn (1956) found the fall in pressure to have been reduced in a number of these patients.

Sub 2 c. Edwards and Edwards (1937) showed that every obstruction due to thrombosis is eventually followed by recanalization, if only to a small extent in some cases. The valves previously present, however, were found to have been destroyed after recanalization.

It was shown by a number of investigators that in the initial stage of thrombosis the venous return is carried on by the collaterals which are not designed to cope with a flow of this magnitude. This will result in dilatation of these veins. Edwards and Edwards (1937) also showed that dilatation of a vein by four-tenths of its width results in incompetence of the valves. In a leg, the femoral vein of which has been affected with thrombosis, the venous blood is therefore drained either through recanalized veins of the thigh or through distended collaterals. Normally functioning valves are not present in these vessels. Accordingly, it will depend on the patency and competence of the popliteal vein whether this incompetence present in the thigh will result in a return flow of the blood which has been forced into this region on contraction of the calf muscles. In the event of an incompetent popliteal vein, the blood present in the thigh will be partially withdrawn.

Summarizing, it can therefore be concluded that the form of impairment referred to under B (p. 29) is attributable to post-thrombotic changes of the deep veins in the greater part of the cases.

The extent to which the various post-thrombotic changes may be differentiated in venous pressure determination will have to be decided by the study of patients.

DIFFERENTATION BETWEEN THE VARIOUS FORMS OF IMPAIRMENT

The examination of patients will also have to show whether the theoretically practicable identification of perforators by pressure determination is feasible and that the venous pump will function normally when the adverse effect of these veins on the pumping action has been eliminated.

The following questions will have to be answered.

1. By how much per cent will the venous pressure, as measured in the erect position, decrease when a subject without venous changes performs walking movements?
2. Can this decrease be affected in normal individuals by applying a tourniquet below the knee or about the ankle? (I.e., by eliminating the saphenous vein and perforators, if any, respectively in relation to the site of pressure determination.)
3. When an increased fall in pressure is produced by applying the tourniquet below the knee in a patient with varices, will this fall markedly increase or not on compression in the region of the ankle?
4. If not, then will perforators also *not* be identifiable in the phlebogram?
5. If so, then will unmistakably incompetent perforators also be identifiable in the phlebogram?
6. When no other changes besides incompetent perforators are identifiable in the phlebogram, then will the pressure fall to normal 'walking levels' on compression in the region of the ankle?
7. Are there phlebographically identifiable post-thrombotic or non-post-thrombotic changes confined to the leg which can also be identified by pressure determination?
8. Is there a mean fall in pressure on walking without compression in a post-thrombotic condition identified by phlebography?
9. Is this fall in pressure affected by compression below the knee or in the region of the ankle?
10. If so, then will incompetence of the superficial venous system or of perforators also be identifiable by X-ray?
11. If not, then has this incompetence not been shown to be present?
12. Will venous pressure determination enable a differentiation between post-thrombotic conditions with and those without recanalization?

Without anticipating the results obtained in this study, it can be stated that *two entirely different conditions may apparently give rise to an identical clinical picture.* The clinical picture of the 'lower leg syndrome': oedema, induration, pigmentation, leg ulcer and varicosis, variously associated with one another, is observed both in incompetence of perforators and in 'incompetence' of the deep veins. The two above conditions each result in impairment of the venous pump to an approximately similar extent. *The obvious conclusion is that these complications are due to impairment of the pumping action.*

This impairment is known to result in a continued increase in venous pressure to the extent that the reabsorption of extracellular fluid is impaired. Wells, Youman et al. (1938) have shown that this condition gives rise to the appearance of oedema which is only absorbed in the recumbent position. The oedema observed in disturbances of the venous circulation therefore is attributable to impairment of the pumping action. The mechanism by which the disturbance is produced is not of importance.

It is assumed without further proof by a large number of authors that long-standing oedema gives rise to induration and ulcer of the leg. It has never been shown, however, that this actually is the case. Moreover, these complications are known to be exceptional in other forms of oedema such as cardiac oedema. Pollack, Taylor, Meyer and Wood determined the venous pressure in cases of congestive heart failure associated with oedema and observed a normal fall of pressure in these cases (1949).

As a rule, the changes described will only occur in cases of long-standing oedema. Bauer (1942) did follow-up studies on 200 patients known to have had thrombosis of the deep veins. His findings were as follows:

	Oedema	*Induration*	*Ulcer*
Within 1 year	in every case	None	None
1—5 years	in every case	60 %	16 %
5—10 years	in every case	75 %	50 %
More than 10 years	in every case	90 %	80 %

This series clearly illustrates again the interval free from symptoms known to occur between thrombosis and the onset of complications.

Two theories may be suggested to explain this interval: the

complications are due to the long-standing oedema, or another factor eventually appears, which factor gives rise to induration and ulcer.

Several authors consider the former theory the most likely. If this point of view should be correct, then treatment should be directed only towards the prevention and disappearance of the oedema.

As this, like all theories on the pathogenesis of ulcers, is merely hypothetical, another point of view should be discussed as well.

The other factor having an adverse effect on the venous system might be the incompetence of certain veins. The term incompetence should be understood here as referring to a condition in which the veins involved no longer contain any valves which close when the pressure in the vessel becomes higher proximal to the valve than it is distal to the latter.

The following forms should be differentiated:

a. incompetence of perforators,
b. incompetence of the popliteal and femoral veins or of distended collaterals in this region.

As stated previously, theoretically this incompetence might cause deficiency of the venous pump (thereby resulting in oedema).

Investigators arguing on theoretical lines have added another factor to which induration and ulcer of the leg might also or solely be due. This is the view suggested by Dodd and Cockett as well as by Piulachs et al., whose theories will now be discussed in greater detail (vide infra).

Sub a. Dodd and Cockett (1956) stressed the importance of the incompetence of perforators in the pathogenesis of ulcer of the leg. Homans (1916) and especially Linton (1938) had previously drawn attention to the causal relationship between this complication and incompetence of these veins. Incompetence due to the destruction of valves or to dilatation of the veins will permit reversal of the direction of the flow. Dodd and Cockett believe the capillary damage assumed to result from an intermittent sudden marked increase in venous pressure occurring during contraction of the calf muscles in the superficial region normally drained by the perforators, to be an important factor in the pathogenesis.

Sub b. Homans (1945) followed by Linton and Hardy (1948) stressed the rôle of incompetence of the deep veins in the pathogenesis of the post-thrombotic syndrome. Linton observed an ulcer appearing within one year after thrombosis in one case only; at operation, recanalization of the femoral vein was found to have occurred already. Congenital or post-thrombotic incompetence of the femoral and popliteal veins was particularly stressed by Bauer (1948) as a factor in the pathogenesis of the leg ulcer.

Piulachs (1956) regards incompetence of the large deep veins as an important factor in the pathogenesis and does so for the following reason. As valves are absent between the large pelvic veins and the veins of the leg, any increase in intra-abdominal pressure such as that resulting from coughing, straining down, lifting etc., will be freely transmitted to the leg.

Piulachs and his associates showed that this transmission actually occurs. This finding was not verified by Höjensgaard and Stürup (1950). Fell (1955), however, reached a similar conclusion.

Piulachs et al. assume that these continual 'pressure waves' will cause damage to the capillaries in the region in which induration and ulcers occur.

The value of these various theories will not be discussed more fully, but the fact should be pointed out that surgical treatment based on these theories and directed towards correction of the changes in question produced satisfactory results in a large number of cases.

In the opinion of the present author, venous pressure determination is of importance in establishing the diagnosis when the main changes which, according to current views such as those of Dodd and Cockett or those of Piulachs et al., play a rôle in the pathogenesis of the above complications, can be identified and differentiated from one another by this procedure.

SUMMARY

In normal individuals as well as in patients showing changes in the venous system, the return flow of venous blood from the legs is similar to that from other parts of the body regardless of the position of the latter. When the subject is at rest in the erect position, however, there will be a marked increase in venous pressure in the distal veins of the lower extremities. In normal conditions,

this pressure will fall within a few seconds when walking movements are performed, as this will set the pumping mechanism of the leg muscles in action.

This pumping mechanism may be impaired by a variety of changes in the venous system of the legs. The severity of any impairment of the action of the venous pump may be determined by measuring the venous pressure. This method of examination might be a valuable diagnostic aid if it were possible to make the measurements in such a way as to differentiate between the various types of changes in the venous system.

III. PERSONAL INVESTIGATIONS

OBJECTIVE

Phlebography in extremities with impaired venous return showed that markedly different changes in the venous system may give rise to identical symptoms. This examination enables only the identification of changes in the visualized veins. It does not furnish any data regarding the extent to which the normal course of events in venous return has been disturbed by these changes.

Venous pressure determinations in patients presenting symptoms of impairment of the venous circulation showed that the presence of particular changes in the deep and/or superficial veins of the leg results in impairment of the pumping mechanism of the leg muscles.

The present study was designed to determine whether the various changes identifiable by phlebography will impair the action of the venous pump and whether a particular change will produce a similar form of impairment in every case. On the other hand, studies were done to determine whether the reverse correlation holds true, i.e. that a specific form of impairment of the action of the venous pump indicates particular anatomical changes identifiable by X-ray.

CASES STUDIED

A total number of 100 extremities were examined in eighty-five patients consisting of forty-four women and forty-one men. The patients were treated in successive order.

Age: from twenty-one to seventy-six, average age forty-six.

In every case, the examination was concerned with extremities in which the history or clinical picture suggested the possible presence of venous disturbances.

In the extremities examined the incidence of the various changes observed in impairment of the venous circulation was as follows:

oedema	in 58 cases,
ulcer	in 42 cases,
varices	in 63 cases,

pigmentation	in 53 cases,
induration	in 46 cases,
pain	in 30 cases.

An examination was made for the following reasons:

Symptoms attributable to a history of thrombosis	in 36 cases
varicosis with ulcer	in 14 cases
recurrent phlebitis	in 6 cases
postoperative recurrence of varices	in 5 cases
oedema of obscure origin	in 13 cases
obscure clinical picture due to impairment of venous circulation	in 16 cases
examination of venous circulation after injury	in 2 cases

The clinical examination was made by the present author himself, who also decided whether phlebography was indicated.

Venous pressure determinations and phlebography were also carried out by the present author in every case.

The X-rays taken were interpreted after consultation with the radiologist.

The venous pressure was measured prior to examination by X-ray.

TECHNIQUE

PHLEBOGRAPHY

Ascending phlebography

1. The patient leans in the erect position with the back and head against the X-ray table placed at an angle of about 65° with the floor. To prevent accidents in the event of collapse, the patient is secured to the table by two straps.

2. The contrast medium is injected into a vein of the foot. In standing patients, direct venipuncture was frequently found to cause difficulties: during injection, the needle pearced the (varicose) vein, the patients complained of pain, failed to keep the leg in its original position and collapse was a common event. This was the reason why direct venipuncture was abandoned for the following method. A vein running between the metatarsals I and II

is exposed through an incision not more than two cm. in length, made at a point a few centimetres proximal to the base of the great and second toes. This vein is present in every case and its calibre is sufficient to pass a polythene catheter having an inner diameter of 0,5 mm. through the lumen. The catheter, having been firmly secured, is connected with an intravenous drip of physiological saline solution. This prevents clotting. The vein communicates freely with the dorsal and plantar venous arches of the foot. The contrast medium injected at this site therefore is distributed throughout the entire foot prior to ascending through the veins of the leg. This ensures adequate filling of the two saphenous veins as well as of the deep veins.

It should be pointed out that the contrast medium was initially injected distalwards into the short saphenous vein behind the lateral malleolus, the injection also being made following venesection. As the necessary incision failed to heal by first intention, however, in too large a number of cases, this method was abandoned. As a rule, the skin at the base of the toes is unchanged, even in patients showing otherwise severe trophic disturbances. Although healing of the incision is complicated by infection of the wound, the sequelae will never be severe in this area.

3. A tourniquet is applied about the ankle. In the opinion of the present author, this will ensure more adequate filling of the deep veins, as less contrast medium will be lost in the superficial venous system, which possibly may be varicose. In addition, the filling of a large number of superficial veins with contrast medium will increase the difficulty of interpreting the phlebogram and frequently prevent the localization of incompetent perforators. Determining the state of the superficial veins by X-ray is difficult and does not have any practical significance.

Occasionally, the resistance encountered during injection of the contrast medium is such (the patient complaining of pain) that the tourniquet has to be removed. In that case, the deep veins of the ankle will be found to be markedly constricted or obliterated.

A tourniquet is not applied below the knee as a routine procedure. It is, however, when fluoroscopy shows, that all contrast medium flows through a perforator to the long saphenous vein and filling of the deep system fails to occur or is inadequate.

4. The leg is bandaged in every case. This measure is designed to prevent stagnation of a large proportion of the contrast medium in varicose superficial veins. Stagnation might occur if the varices were not sufficiently compressed, especially in the case of incompetent perforators and also if the tourniquet around the ankle should fail to obstruct the flow to a sufficient extent. This would impede the localization of incompetent perforators.

5. Thirty ml. of 76 per cent 'urografin' are injected as rapidly as possible, usually within sixty seconds. As a rule, this produces a phlebogram readily interpretable as far as a point just below the groin.

Filling of the deep femoral vein is only observed in exceptional cases.

6. Exposures are made during *fluoroscopy*. This is of special importance in timing the exposures.

The first exposures are made when adequate filling of the deep veins of the lower leg has occurred. The second series of exposures are made when the contrast medium has reached the knee. The third series are mainly concerned with the region of the popliteal vein, the fourth with the thigh. Two *stereoscopic* X-ray pictures are taken at intervals of a few seconds in every case.

Stereoscopic viewing of phlebograms, particularly those of the leg, is considered an improvement in technique: it is the only method affording a true spatial visualization of the state of the circulation, especially in extremities characterized by varicose changes and partial obliteration of the deep veins.,

7. After a part of the contrast medium has reached the veins of the leg and the first exposures have been made, the patient is requested to move the foot a few times prior to making the second series of exposures. As stated previously, this is designed to produce visualization of incompetent perforators, if any, and to improve the flow of the contrast medium. When adequate filling of the popliteal vein has, occurred, the patient is requested to strain, a similar procedure being adopted in the case of the femoral vein. This usually affords visualization of one or several valves in the veins in question.

Descending phlebography

1. The position assumed by the patient is similar to that adopted in ascending phlebography. The reason why this position is preferred was stated previously. Twenty ml. of 76 per cent 'urografin' are used.

2. The contrast medium is injected into the common femoral vein through a polythene catheter having an inner diameter of 1 mm., which is passed through the long saphenous vein. This requires venesection in the inguinal region. When phlebography has been completed, the saphenous vein is closed with a tobacco-bag suture to preserve the continuity of this vein.

When the saphenous vein is absent as the result of an operation performed in this region, it will usually be possible to dissect out another branch of the femoral vein to pass the catheter through.

3. As soon as fluoroscopy shows that a small amount of contrast medium is present in the femoral vein, the patient is requested to strain down vigorously until a rapid exposure has been made. When valves are present, the contrast medium will accumulate above these. Part of the contrast medium usually passes one or several valves, certainly when the patient strains down vigorously, but especially when he strains intermittently. For reasons to be specified further on, no value is attached to this fact. When retrograde filling of the superficial and deep femoral veins or of regional collaterals results without visualization of valves, the condition is assumed to be pathological.

Pelvic veins

A perceptible degree of filling of the iliac vein is occasionally observed in the exposures made immediately after the patient has ceased to strain in descending phlebography. This certainly is not the rule. If the patient does not strain, the iliac vein (if present) will be plainly perceptible in exposures taken immediately after injection of the contrast medium into the femoral vein. When a large number of distended collaterals are detected in this region, it is concluded that the iliac vein has been obliterated. The patient is in the recumbent position during these exposures.

Comment

The method described was used in the examination of about 250 extremities. Also in view of what has been stated on the subject in Chapter I, the present author believes that this technique will usually provide adequate information on the condition of the venous system.

It is possible, however, that the phlebogram obtained is not completely reliable. For instance, when the superficial veins in the region of the ankle are not sufficiently compressed, it may happen that the concentration of the contrast medium flowing into the deep veins of the leg will be inadequate. This may also occur when a large part of the contrast medium flows to the superficial veins of the leg through incompetent perforators. This may wrongly suggest that the deep veins are not patent.

In some cases, it is not possible to obtain an appreciable degree of filling of the popliteal and femoral veins in extremities characterized by markedly distended veins of the foot and leg.

Even in the event of adequate filling of the deep veins of the leg, there remains a possibility that incompetent perforators are not perceptible in the phlebogram. Though this was found to be exceptional in personal surgical cases, this contingency should be taken into account.

VENOUS PRESSURE DETERMINATION

The following method was adopted in making venous pressure determinations. The pressure is measured in a distal vein of the upper surface of the foot, using the vein running between the first and second metatarsals referred to in the discussion of phlebography. The polythene catheter used in phlebography is connected with a glass graduated tube filled with physiological saline solution which can be refilled by a three-way cock after each reduction.

The pressure, which is expressed in cm. of water, is determined after the patient has been standing for so long that the fluid in the graduated tube remains at the same level.

The patient then is requested to perform walking movements. When this results in a fall in pressure, the patient is asked to continue until the pressure ceases to fall. The level then obtained is recorded and the tube is refilled with fluid to prevent reflux of blood during the following increase in pressure. Subsequently,

the effect of the saphenous system is eliminated by applying a tourniquet below the knee. In the event of clinically perceptible incompetence of the short saphenous vein, compression may be applied first above and then below the knee to enable individual examination of the state of this vein. The level attained is again recorded after the patient has performed walking movements.

Finally, the tourniquet is applied about the ankle in the region of the malleoli and the level attained on walking is recorded.

The fall in pressure, expressed in cm. of water, will naturally be dependent on the initial level, i.e., on the height of the patient. In order to eliminate this factor, the practice of expressing the fall in percentages of the standing pressure was adopted.

The determinations made are designated as follows.

S.V.P. : 'standing venous pressure', the venous pressure expressed in cm. of water after the patient has been standing.

W.V.P. I: 'walking venous pressure I', the fall in pressure expressed in percentages of the S.V.P., obtained by having the patient perform walking movements without compression.

W.V.P. II: the same, with compression below the knee.

W.V.P. III: the same, with compression about the ankle.

Observations during the fall in venous pressure

In certain cases and especially when impairment of function is not very severe, it may be useful to determine the time required to produce a maximum fall in pressure. A number of investigators always report this time in conjunction with other data. The present author has not done so for the following reason: normally, the initial fall in pressure, occurring when the subject examined performs walking movements, is rapid, being about 3 cm. after each step; this rate gradually decreases to a few mm. following each step. In the opinion of the present author there would therefore be more point in recording the difference in time between W.V.P. I and II for the first thirty cm. or, better still, in recording the time required by the patient to attain the fall produced in W.V.P. I following compression of the superficial veins.

Another observation can be made when the venous pressure falls; normally, walking results in a uniform fall in pressure which

decreases when the calf muscles are relaxed and rises slightly when they contract. In the event of 'leakage' from perforators, this will be immediately perceptible, as the increase during contractions will be abnormally marked, the rise in pressure being approximately equivalent to the fall during relaxation in some cases. This phenomenon is also observed in incompetence of the saphenous vein and in most cases of incompetence of the deep veins. The variations due to incompetence of the saphenous vein will disappear when a tourniquet is applied below the knee, those caused by the perforators will disappear when compression is applied at the ankle and those due to 'deep incompetence' will persist. As a result, examination will show whether the main impairment in function of the pump has been corrected.

Comment

This procedure was used in the examination of 100 extremities of patients who were treated in successive order. Efforts were made to keep the technique as simple as possible so as to develop venous pressure determination into a practicable method.

No difficulties were encountered in interpreting the findings obtained in examination, though incorrect recording is possible. For when a tourniquet is applied around the leg in determination of the W.V.P. II and III, it may be secured either too tightly or too loosely. The latter will be particularly liable to occur when the leg is highly oedematous. This may be remedied by having the patient rest in bed for a day, with elevation of the leg to be examined. In these cases, it is particularly advisable to repeat the examination a few times in order to determine whether tighter constriction will result in different findings. There is not much risk of the compression being too tight. In this case, the deep veins might become constricted as well. To produce this effect, the tourniquet would have to be tightened to such an extent that the patient complains of pain immediately, a fact also observed in phlebography. This pain increases as walking movements are performed and if the venous pressure is measured at that moment, a rise in pressure will usually be observed.

This does not alter the fact, however, that this might affect the reliability of the results obtained, particularly when the examiner is not sufficiently attentive.

COMPLICATIONS

Severe complications were not observed in any of the patients examined by these methods. Complications may occur, however, particularly as a result of venesection, injection of the contrast medium or collapse of the patient during examination.

Venesection. Most patients did not interrupt their daily work after examination, despite the presence of a sutured wound in the foot. When a follow-up was done seven days later, the dressing and the area surrounding the wound were constantly found to have become soiled to a considerable extent. The failure of the wound to heal by first intention in at least twenty per cent of the cases is attributable to this soiling but also to the fact that, in patients with ulcers, venesection is performed in contaminated areas.

There was only one case in which this caused prolonged infection. This concerned a patient with severe arterial insufficiency in addition to the changes in the veins. It took two months for the wound to heal.

The wound caused by venesection in the groin preliminary to descending phlebography was infected in one case only. Venesection was followed by a fairly severe haemorrhage from the wound in the groin in one case in which it gave rise to a large haematoma.

The contrast medium. Sensitivity reactions were absent in every case. Some patients complain of pain in the calf during examination. Residual symptoms nor phlebitis due to irritation of the wall of the vessel by the contrast medium were observed.

Collapse. Collapse was never observed during phlebography. A highly nervous woman collapsed during venous pressure determination. The following interesting observation was made in this case: when the patient showed the prodromes of collapse, a rapid fall in pressure in the vein of the foot occurred. This fall in pressure continued when she seated herself with her head between the knees. The pressure fell to about 30 cm. H_2O.

The patients referred to in the first part of this chapter all were examined using the above methods. In order to determine the extent to which there is a correlation between the results obtained

in phlebography and venous pressure readings, the patients were classified into a number of groups, this classification being based on the findings in phlebography. In certain cases, viz., when the only lesion consisted in clinically identifiable varicosis and in patients with lymphoedema, the classification was also based on the data obtained in physical examination.

CLASSIFICATION

Group Ia : clinical examination failed to reveal any changes positively attributable to impairment of the venous circulation, absence of changes in the phlebogram.

Group Ib : no clinical changes in the extremity, distended veins in the inguinal region, changes in the veins of the thigh and leg absent in the phlebogram, presence of changes in the region of the iliac vein.

Group II : clinically detectable impairment of the venous circulation, deep system normal in the phlebogram, one or several incompetent perforators.

Group III : similar clinical picture, changes in the phlebogram (obstruction and varicosis) confined to the deep veins of the *leg*.

Group IV : similar clinical picture, changes in the phlebogram similar to those in the previous group, but associated with incompetent perforators.

Group V : similar clinical picture, post-thrombotic changes in the veins of the *leg and thigh*, no incompetent perforators.

Group VI : similar clinical picture, changes in the phlebogram similar to those in the previous group, but presence of incompetent perforators.

Group VII : oedema of the leg conveying the impression of being lymphoedema on clinical examination in most cases, absence of changes in the phlebogram.

Group VIII: clinical examination revealed primary varicosis, changes of the deep veins absent in the phlebogram.

The above classification includes the statement 'similar clinical picture' for several groups; this is illustrated in the following survey of the incidence of the various changes:

Group	Number of cases	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
I	7	0	1	0	0	0	0
II	17	7	7	16	12	10	3
III	12	6	6	12	9	7	6
IV	7	3	2	6	2	2	2
V	24	20	16	12	16	17	12
VI	15	13	8	11	13	10	6
VII	7	7	0	0	0	0	0
VIII	6	2	2	6	1	0	0

Accordingly, the incidence of ulcers, pigmentation and induration is approximately identical in groups II, III, IV, V and VI. Though this cannot be clearly expressed in figures, it should be pointed out that on the whole the symptoms were the most severe in the post-thrombotic groups.

RESULTS OBTAINED IN EXAMINATION OF THE VARIOUS GROUPS

GROUP I a

Number of cases: four.

Though the history and clinical examination had not produced any data suggesting impairment of the venous circulation in these cases, examination of the venous system was nevertheless assumed to be indicated. Changes of the deep veins were absent in the phlebograms. (cf. Figs. XIII, XIV and XV)

VENOUS PRESSURE DETERMINATION

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
v. B.	133	60	60	60	—	—	—	—	—	—
B.—R.	123	64	64	64	—	—	—	—	—	+
v. D.	138	53	55	55	—	—	—	—	—	—
K.	130	42	42	47	—	+	—	—	—	—

Comment: the mean levels in this group are:

S.V.P. : 131 (123—138)
W.V.P. I: 55 (42— 64)
W.V.P. II: 55 (42— 64)
W.V.P. III: 56 (47— 64)

Using the method adopted by the present author, the normal fall in venous pressure when walking movements are performed,

apparently is from fifty to sixty per cent. As this is in accordance with the findings reported by others, no normal subjects were examined.

Application of a tourniquet below the knee or about the ankle has little if any effect on the fall in pressure.

GROUP I b

Number of cases: three.

History. Of these patients, two had sustained an injury to the iliac vein more than six months previously. The third had had oedema of the left leg following appendectomy ten years previously.

Examination. None of these patients showed changes in the legs suggesting venous disorders. In two cases distended veins were perceptible in the inguinal region.

Phlebogram. Phlebography failed to reveal any changes in the veins of the leg and thigh; collaterals were detectable in the region of the iliac vein, so that thrombosis may be assumed to have occurred in this vein.

VENOUS PRESSURE DETERMINATION

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
C.	128	60	60	60	—	—	—	—	—	—
V.	122	62	62	62	—	—	—	—	—	—
K.	124	63	63	63	—	—	—	—	—	—

Comment: it can be concluded from the findings in these three cases that *post-thrombotic changes of the iliac vein apparently do not necessarily result in impairment of function of the venous system of the legs.*

GROUP II

Number of cases: seventeen.

History. The possibility of thrombosis could not be definitely ruled out in six of these patients.

Examination. The greater part of these patients showed changes characteristic of a lower leg syndrome. Inspection and palpation revealed the presence of incompetent perforators in eight cases.

Accordingly, the history and clinical picture frequently failed to indicate the pathogenesis of the identifiable changes.

Phlebogram. Phlebography *failed to reveal any changes in the deep venous system* in these cases. Valves were identifiable in the popliteal and femoral veins in every case. *Incompetent communications between the deep* and (nearly always varicose) *superficial system* were present in all patients (cf. Figs. XX and XXII).

VENOUS PRESSURE DETERMINATION

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
v. d. B.	130	51	60	70	—	—	+	+	+	—
d. B.	136	40	56	60	—	+	+	—	—	+
id.	136	29	29	60	—	+	+	—	—	+
B.	132	32	40	50	—	—	+	+	+	—
v. D.	126	40	44	55	+	—	+	+	+	—
D.	134	49	65	70	+	—	+	+	+	—
v. E.	126	20	41	57	—	—	+	—	—	—
F.	128	30	30	60	+	—	—	—	—	+
v. H.	137	10	47	51	—	+	+	+	+	—
d. K.	131	22	37	53	+	+	+	+	+	—
S.	151	51	54	80	+	+	+	+	+	—
T.	125	40	54	72	—	+	+	+	—	—
V.	120	20	33	60	—	—	+	—	—	—
v. V.	132	32	50	70	—	—	+	+	+	—
V.	126	20	35	51	+	—	+	+	+	—
W.	138	16	27	63	+	+	+	+	+	—
Z.	112	44	50	61	—	—	+	+	—	—

Comment: the mean levels in these cases are:

S.V.P. : 132 (120—151)
W.V.P. I: 32 (10— 51)
W.V.P. II: 42.5 (27— 65)
W.V.P. III: 61 (50— 80)

Accordingly, the deep system of these patients is capable of functioning normally provided, firstly, the incompetent saphenous vein and, secondly, the incompetent perforator(s) has (have) been eliminated. This results in an average increase of the fall in pressure to twice the initial value. In considering the results, the fact that the fall in pressure is enhanced by compression in the region of the ankle rather than by compression in the region of the knee, is a striking feature. When the results obtained in this group are

compared with those obtained in group VIII, the impression is also gained *that the impairment of the pumping action due to varices is less severe than that caused by incompetent perforators.* This naturally varies with the individual case, depending on the severity of the varicosis and the size of the perforator. The difference of the fall in pressure recorded in W.V.P. II and III is not only reflected in the extent to which the pressure has fallen, but also in the rate at which the fall in pressure occurs; in case 4 (v.D.), for instance, the pressure fell three times as rapidly when compression was applied about the ankle as it did when compression was applied in the region of the knee.

In view of the results obtained in venous pressure determination, the lower leg syndrome is believed to have occurred without any marked changes in the deep veins of these patients with incompetent perforators. This is at variance with the findings as reported by Höjensgaard and Stürup who believe the disturbance of the fall in pressure in patients with incompetent perforators to be due to the changes in the deep veins of the leg, which changes are claimed by these authors to be present in all cases of this type.

GROUP III

Number of cases: twelve.

History. A striking feature consisted in the fact that five of these patients had previously undergone surgical treatment for varicosis. Bursting pain (intense pain occurring in the erect position, the patient experiencing a sense of tension in the calf), regarded by some as the outstanding symptom of incompetence of the popliteal vein, was present in six cases.

Examination. The clinical picture in these cases was similar to that in group II.

Phlebogram. The ascending phlebogram showed changes in the deep veins of the leg in every case (obliteration and varicosis). Incompetent perforators were not observed in these patients, the popliteal and femoral veins presented a normal appearance and had valves in every case (cf. Figs. XVIII, XXIII and XI).

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
H.	118	10	34	8	—	+	+	+	+	+
d. K.	131	5	26	26	+	+	+	+	+	—
id.	122	17	30	30	—	—	+	+	+	+
M.	134	21	46	46	+	+	+	+	—	—
d. M.	123	31	37	40	+	—	+	+	+	+
v.d. R.	137	11	52	48	—	—	+	—	—	+
v. V.	130	24	30	29	—	+	+	+	+	—
id.	130	3	23	20	—	+	+	+	+	—
V.	132	35	35	43	+	—	+	—	—	+
A.	153	30	55	30	+	—	+	+	—	—
V.	129	11	34	34	+	—	+	+	+	—
G.	136	22	47	37	—	+	+	+	+	—

Comment: The changes identified by X-ray in the deep veins of the leg probably are partially attributable to the fact that the patients had previously had phlebitis. In a number of cases, they were believed to be due to treatment with sclerosing solutions. Similar lesions have been reported by others as well (Mathiesen, 1959). There also are a number of cases, however, in which the appearance of varicose changes in the muscle veins cannot be traced to any specific cause. It is quite possible that these were cases of primary deep varicosis.

The mean levels recorded in venous pressure determination were:

S.V.P. : 132 (115—147)
W.V.P. I: 18 (5— 35)
W.V.P. II: 40 (26— 55)
W.V.P. III: 32.5 (8— 48)

The fall in pressure produced by walking was below normal in all these patients. Compression of the incompetent saphenous vein below the knee had a beneficial effect in most cases. In one case, this was merely reflected in the time required to produce the pressure fall: case 7 (V.): W.V.P. I one min. ,W.V.P. II thirty sec. Compression of the superficial veins in the region of the ankle did not further increase the beneficial effect in most cases. In comparison with the values resulting from compression in the region of the knee, there even was a slight average rise in pressure. This increase, however, is not statistically significant.

In patients in whom compression of the superficial veins in the region of the ankle has an adverse effect, these veins may be regarded as being essential to the return of venous blood from the foot.

In view of the results obtained in venous pressure determination, superficial incompetence is likely to be associated with impairment of the pumping mechanism localized in the deep veins in these cases. This is in accordance with the X-ray findings.

Dodd and Cockett as well as Höjensgaard and Stürup believe the impairment of the pumping action following thrombosis to be due to changes in the deep veins of the leg. In this group of cases, however, the impairment of the pumping action caused by changes *localized solely in the leg* is not so severe as the impairment of function observed in patients showing post-thrombotic changes in *the leg and thigh* (groups V and VI).

In conclusion, it should be stated that it is the belief of the present author that the prognosis following surgical elimination of the superficial incompetent veins cannot be expected to be good in patients of this group, as the pumping action will continue to be impaired after this form of treatment. The extent to which the pumping action was improved as a result of this procedure in patients who had previously undergone surgical treatment naturally cannot be determined. It was a striking fact, however, that compression of the recurrent varices resulted in improvement of the pumping action in every case of this type.

GROUP IV

Number of cases: seven.

History. Three of these cases were treated for recurrence of symptoms following surgical treatment.

Examination. The clinical picture was similar to that in the two previous groups.

Phlebogram. Changes in the deep veins of the leg (obstruction and varicosis), one or several incompetent perforators of the leg. The popliteal and femoral veins constantly showed a normal appearance, were normally localized and contained valves (cf. Figs. XVII, IV and VI).

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
H.—B.	147	16	28	43	—	—	+	—	—	—
Z.	129	12	20	40	—	+	+	+	+	—
v. D.	128	17	21	28	+	+	—	+	+	—
V.	132	29	43	50	+	—	+	—	—	+
H.	129	32	27	43	—	—	+	—	—	—
P.	127	21	45	30	—	—	+	—	—	—
v. D.	132	24	29	42	+	—	+	—	—	—

Comment: In these cases the mean levels were:

S.V.P. : 132 (115—147)
W.V.P. I: 21.5 (12— 32)
W.V.P. II: 30 (20— 45)
W.V.P. III: 39.5 (28— 50)

Accordingly, the levels recorded in the patients of this group also are below normal.

Elimination of the saphenous vein is found to have a beneficial effect in most cases, resulting in an average increase of the fall in venous pressure by 10 per cent. Elimination of the incompetent perforator also has a beneficial effect in six out of seven cases. The subsequent fall in pressure is equivalent to that resulting from compression in the region of the knee. It cannot be ascertained whether the case which proved an exception is due to incorrect observation or to insufficiency of the deep veins in the region of the ankle.

Though the function of the venous system can also be improved in these cases by elimination of superficial incompetence, a disturbance persists, which is attributable to the anatomical changes in the deep veins of the leg identified by X-ray. The prognosis again is not likely to be good in these cases.

It should be pointed out that this small group of patients, seven per cent of the total number of cases, is the only group satisfying the criteria adopted by Dodd and Cockett, Höjensgaard and Stürup, Eckstein and Brands (1959); viz., that incompetent perforators should always be associated with changes in the deep veins of the leg. The study of the two previous groups showed that these two types of changes may also occur individually, each being

characterized by a distinctive X-ray picture and pressure determination pattern.

GROUP V

Number of cases: twenty-three.

History. The history of most of these patients suggested that the changes observed were due to earlier thrombosis. Three patients positively denied ever having had thrombosis, four were not sure.

Only fifty per cent of the patients complained of pain in the calf, typical bursting pain was exceptional.

Examination. The greater part of the patients showed severe changes; this group included sixteen of the forty-two patients with ulcers. The incidence of the accompanying pigmentation and induration was approximately equal to that in group II.

Another feature deserving mention is, that varicose superficial veins were only observed in fifty per cent of these cases.

Phlebogram. Severe post-thrombotic changes consisting in obstruction, a tortuous course, absence of valves and abnormal localization, extending to the popliteal and femoral veins (cf. Figs. X and IX). Though as a rule the veins of the leg were clearly perceptible and the state of these veins could be readily determined, incompetent perforators were not identified; on the contrary, the region in which the incompetent perforators are usually localized was frequently found to show a normal appearance whereas the changes identifiable by X-ray did not commence until the upper two-thirds of the leg (cf. Fig. VIII).

Fluoroscopy frequently showed that the contrast medium was forced back as far as the leg from the veins of the thigh whenever the patient was requested to strain. A valve was never observed in the descending phlebogram between the sapheno-femoral junction and the distalmost point reached by the contrast medium, usually the popliteal vein (cf. Fig. XIX).

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
v. B.	127	2	2	4	+	+	+	+	+	+
B.	146	0	0	0	+	+	+	+	+	—
B.	120	10	10	10	—	+	+	+	+	+
E.	135	24	15	20	+	—	—	+	—	—
d. J.	151	10	10	10	+	—	—	—	+	+
K.	130	30	14	14	—	+	—	—	—	—
v. L.	125	1	4	3	+	+	—	—	+	—
L.	131	22	12	0	—	+	—	—	—	—
M.	133	28	28	34	+	—	+	+	+	—
M.	139	2	0	0	+	+	—	+	+	—
N.	135	0	2	4	+	+	+	+	+	—
id.	135	2	0	0	+	+	+	+	+	—
S.	120	0	0	0	+	—	—	—	—	+
T.	138	0	0	0	+	+	—	+	+	+
V.	122	0	0	0	+	+	+	+	+	—
V.	126	41	13	13	+	—	—	—	+	+
d. W.	132	15	15	15	—	+	+	+	+	—
W.	130	0	0	0	+	+	+	+	+	+
id.	130	0	0	0	+	+	+	+	+	+
v. W.	133	14	16	16	+	—	+	+	+	+
W.	132	1	0	0	+	—	+	+	+	+
Z.	133	7	7	12	+	+	—	+	+	+
v.d. Z.	146	0	0	0	+	+	—	—	—	—

Comment: the mean levels recorded in this group were:

S.V.P. : 136 (120—151)
W.V.P. I: 9 (0— 41)
W.V.P. II: 6 (0— 28)
W.V.P. III: 6 (0— 34)

These values differ markedly from the falls in pressure produced so far. To begin with, there is the fact that walking without a tourniquet only gives rise to an appreciable fall in pressure in exceptional cases. This slight fall in pressure is not increased by applying a tourniquet below the knee. In those cases in which the W.V.P. I still showed a fair fall in pressure (seven patients), compression definitely had an adverse effect in four cases. *The superficial venous system therefore apparently is an essential factor in the fall in pressure caused by walking.* In case 16 (V), the superficial veins apparently are capable of producing a virtually normal fall in pressure.

In this group, it does not make any difference whether the tour-

niquet is applied below the knee or around the ankle and there is no statistically significant difference between the fall in pressure with and that without elimination of the superficial system.

A striking feature in case 9 (M.) is that the fall in pressure is considerable whether or not the superficial veins are compressed. This woman had had severe indurated oedema of the leg for over ten years. The ascending phlebogram showed obliteration of the greater part of the deep system, the contrast medium flowing proximalward through superficial veins despite the application of tourniquets. The pressure determinations designated W.V.P. II and III may be assumed to be not entirely reliable, as compression of the superficial veins was almost impossible in this case owing to the indurated oedema.

GROUP VI

Number of cases: fifteen.

History. All but two patients stated having had thrombosis. Six complained of bursting pain.

Examination. The clinical picture in these cases did not differ from that in group V. Incompetent perforators were observed in nine cases.

Phlebogram. Severe changes, consisting in obliteration, a tortuous course, absence of valves and abnormal localization, in the thigh and leg. An incompetent perforator was plainly perceptible in the region medial to the ankle in every case (cf. Figs. V and XVII).

VENOUS PRESSURE DETERMINATION

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
v.d. B.	147	6	0	0	+	+	—	+	+	—
G.	139	4	0	7	+	+	+	+	—	+
K.	139	6	0	6	+	+	—	+	+	+
K.	142	13	0	21	+	—	+	+	+	—
id.	141	23	20	5	+	—	+	+	+	—
v.d. L.	130	12	10	23	+	—	+	+	—	—
id.	130	12	12	42	+	—	+	+	—	—
v.d. L.	155	14	19	19	+	—	—	—	—	+
L.	148	0	8	20	+	+	+	+	+	—
M.	148	4	0	6	+	—	+	+	+	—
N.	135	14	16	25	+	—	+	—	+	—
S.	136	+7	+14	+3	—	+	—	+	—	+
d. W.	132	19	9	35	—	+	+	+	+	—
W.	137	25	17	25	+	+	+	—	—	+
id.	137	0	+1	7	+	+	+	—	—	+

Comment: the mean levels in this group are:

S.V.P.	: 139	(130—155)
W.V.P. I:	10	(+7— 25)
W.V.P. II:	6.5	(+14— 20)
W.V.P. III:	16	(+3— 42)

The mean W.V.P. I and II levels are similar to those in the previous group in every case. Once again, elimination of the superficial system in the region of the knee fails to produce a statistically significant fall in pressure in this group. When the entire group is considered, application of a tourniquet about the ankle does not produce any significant difference of fall in pressure in comparison with W.V.P. I and II. It is a striking fact, however, that, in a number of cases, the fall in W.V.P. III is greater than that which might be anticipated in this post-thrombotic group. This unexpectedly marked fall in pressure occurs when the perforator is eliminated in relation to the point of measurement. The phlebogram failed to account for this fact; in any case, the degree to which to the deep system was damaged was not found to vary markedly. Case 5 (v.d. L.), for instance, showed very severe post-thrombotic changes in the veins of the leg and thigh. This problem will be referred to again on p. 73.

Case 10 (S.) showed a marked increase in pressure during walking. Compression of the superficial veins was accompanied by an increased rise in pressure, the patient complaining of intense pain in the calf. The ascending phlebogram revealed post-thrombotic changes in the deep veins of the leg and neither the popliteal vein nor the veins of the thigh were filled. The descending phlebogram showed adequate filling in the region of the deep femoral vein and several valves, whereas there was no filling of the superficial femoral vein. Accordingly, the increase in pressure observed probably was due to the obstruction of large veins and inadequate development of collaterals.

It should be noted in passing that the changes observed probably were due to the injection of sclerosing agents and that the findings in venous pressure determination were possibly affected by the bilateral sympathectomy which the patient had undergone a few years previously.

In conclusion, attention should be drawn to the fact that venous pressure determination frequently reveals the presence of incom-

petent perforators in patients with post-thrombotic legs, whereas the presence of these incompetent perforators cannot be definitely ruled out by this method.

GROUP VII

Number of cases: seven.

History. Six patients were treated for oedema of the leg, for which no cause had been detected on general examination. In case 6 (H.), the oedema had appeared after stripping of varices.

Examination. The oedema showed the characteristic features of lymphoedema in five cases. A sure diagnosis was not established in case 7 (v. B.).

Phlebogram. No changes, except in case 4 (v.W.) in which the veins of the lower fourth of the leg did not show adequate filling.

VENOUS PRESSURE DETERMINATION

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
B.	122	37	44	37	+	—	—	—	—	—
B.	130	48	55	37	+	—	—	—	—	—
v. G.	117	48	48	48	+	—	—	—	—	—
v. W.	120	38	38	38	+	—	—	—	—	—
S.	130	44	37	37	+	—	—	—	—	—
H.	120	50	50	50	+	—	—	—	—	—
v. B.	138	60	60	60	+	—	—	—	—	—

Comment: the mean levels in these cases were:

S.V.P. : 125 (120—138)
W.V.P. I: 46.5 (37— 60)
W.V.P. II: 47.5 (38— 60)
W.V.P. III: 44 (37— 60)

The results obtained in these cases are disappointing in that the values are lower than normal despite the fact that the venous system may be assumed not to be impaired. The disturbance possibly is attributable to the inadequate effect of the muscular contractions on the veins of the leg, resulting from the disability caused by the oedema.

In conclusion, it should be pointed out that the application of tourniquets at various levels also did not produce any marked changes in this group.

GROUP VIII

Number of cases: six.

History. One patient stated having had thrombosis.

Examination. All patients showed varicosis of one or both saphenous veins. The changes were less severe than those in groups II, III, IV, V and VI, though there were two cases of ulcer.

Phlebogram. Normal deep venous system in the leg and thigh, absence of incompetent perforators.

VENOUS PRESSURE DETERMINATION

Case	S.V.P.	W.V.P. I	II	III	Oedema	Ulcer	Varicosis	Pigmentation	Induration	Pain
v. P.	140	50	75	78	—	—	+	—	—	—
P.	117	30	67	67	—	—	+	—	—	—
H.	112	50	57	57	+	+	+	—	—	—
B.	127	50	58	58	—	—	+	—	—	—
v. D.	117	35	47	49	+	—	+	—	—	—
V.	130	29	45	50	—	+	+	—	—	—

Comment: To begin with, this group unfortunately is very small. Attempts were naturally made to examine a number of patients of this group to compare the results obtained in venous pressure determination in these cases with those obtained in group II. For it was essential positively to show *that there is no marked difference between W.V.P. II and III in cases in which the deep venous system is normal and phlebography has not revealed any incompetent perforators*, clinical examination also failing to provide any evidence of complication of the varices by incompetent perforators.

This group is too small owing to the fact that it was not considered justifiable to examine patients in whom this procedure was not indicated for reasons of personal interest alone. Moreover of those with primary varices without incompetent perforators some did show changes in the deep veins in the phlebogram. Group III comprises these cases.

The mean levels in these cases were:

S.V.P. : 124 (112—140)
W.V.P. I: 41 (29— 50)
W.V.P. II: 58 (45— 75)
W.V.P. III: 59 (49— 78)

These values show that, on the whole, the function of the venous pump has not been severely impaired, as the W.V.P. I may be regarded as normal in three out of six cases. Elimination of the incompetent superficial veins in the region of the knee has a markedly beneficial effect; the resulting average difference of the fall in pressure is 17.5 per cent. This beneficial effect on the pumping action is also reflected in the time required to produce a particular fall in pressure. In cases 1 (v.P.) and 4 (B.), the difference of time between W.V.P. I and II was 3.5 — 1.5 and 3.5 — 2 minutes respectively.

Transferring the tourniquet to the ankle fails to cause any significant further fall in pressure. There was not a single case in which this manifested itself either in the extent to which the pressure fell or in the time.

CONCLUSION

The present study shows that there is an unmistakable correlation between the findings in phlebography and those in venous pressure determination. The results obtained may be summarized as follows.

In subjects not showing any changes in the venous system of the lower extremity, the performance of walking movements results in a fall in venous pressure as measured in a vein of the foot by at least fifty per cent of the pressure as determined in the motionless erect position. This fall in pressure does not increase or decrease when the superficial venous system is compressed by a tourniquet applied below the knee or about the ankle.

As a rule, the action of the venous pump is not seriously impaired in patients with primary varices not showing changes in the deep veins identifiable by X-ray and without any incompetent perforators detectable by clinical or X-ray examination. Compression of superficial veins by a tourniquet applied below the knee results in a normal fall in pressure during walking. Compression about the ankle has a similar effect.

Primary varicosis may be complicated by incompetence of perforators in the leg, no changes in the deep veins of the leg being identifiable by X-ray. The action of the venous pump usually is more severely impaired in patients showing this clinical picture than it is when incompetent perforators are absent. Compression of the long saphenous vein below the knee does not result in a normal fall in pressure in these cases, whereas compression in the region of the ankle will produce a completely normal fall in pressure.

When superficial varicosis is accompanied by changes in the deep veins identifiable by X-ray, the action of the venous pump will be found to be impaired; this will also be the case following compression of the superficial veins below the knee or about the ankle. There is a marked difference between the fall in venous pressure as determined in patients only showing changes of the deep veins of the leg and that measured in those showing changes localized both in the leg and the thigh.

In patients showing changes in the deep veins of the leg in whom

perforators are absent, the fall in pressure may be increased by the elimination of superficial varices. When perforators are present, compression in the region of the ankle will result in an optimum fall in pressure, which will be from thirty to forty per cent in these cases.

When the entire deep system shows changes (post-thrombotic leg), the fall in pressure will be very slight, when compression is not applied, being not more than twenty per cent with a few exceptions. The effect of compression on this fall in pressure usually is adverse rather than beneficial, though on the whole this effect is not significant. (This will be discussed in greater detail on p. 73). The presence of incompetent perforators cannot be ruled out by venous pressure determination in these extremities, as application of a tourniquet about the ankle fails to increase the fall in pressure in a number of cases, although examination by X-ray has revealed the presence of an incompetent perforator.

Post-thrombotic changes in the region of the iliac vein will not necessarily have an adverse effect on the function of the venous system in the homolateral extremity when this venous system does not show any other changes.

Summarizing, it can therefore be concluded that, on the whole, there is a correlation between the findings in phlebography and venous pressure readings. Will venous pressure determination conversely provide data enabling the classification of a patient with any of the groups described? To find this out, the patients of the various groups were compared in the table on p. 62 as regards the fall in pressure as measured in W.V.P. III.

Venous pressure determination is found to warrant the following conclusions.

When the fall in pressure is less than 25 per cent, the patient will almost certainly be of groups V or VI, while there is a slight chance of his belonging to III or IV. When the fall in pressure is from 25 to 50 per cent, the patient is very likely to be classifiable with groups III or IV. The possibility of his belonging to group VII should be considered as well. As this is the lymphoedema group, there is no reason to expect difficulties. Possible confusion with patients of group VI, characterized by a very satisfactory venous return through the superficial system may be prevented by applying a tourniquet below the knee as well in measuring W.V.P. III.

Fall in w.v.p. III in % of s.v.p.	Cases of group							
	I	II	III	IV	V	VI	VII	VIII
0— 4	0	0	0	0	14	2	0	0
5— 9	0	0	1	0	0	5	0	0
10—14	0	0	0	0	5	0	0	0
15—19	0	0	0	2	2	1	0	0
20—24	0	0	1	0	1	3	0	0
25—29	0	0	2	1	0	2	0	0
30—34	0	0	3	1	1	0	0	0
35—39	0	0	1	0	0	1	4	0
40—44	0	0	2	4	0	1	0	0
45—49	1	0	2	0	0	0	1	1
50—54	0	4	0	1	0	0	1	1
55—59	1	2	0	0	0	0	0	2
60—64	5	6	0	0	0	0	1	0
65—69	0	0	0	0	0	0	0	1
70—74	0	4	0	0	0	0	0	0
75—79	0	0	0	0	0	0	0	1
80—84	0	1	0	0	0	0	0	0
0—24	0	0	2	0	22	11	0	0
25—49	1	0	10	6	1	4	5	1
50—84	6	17	0	1	0	0	2	5

Accordingly, patients with impairment of the venous circulation may be readily differentiated by the results obtained in venous pressure determination.

Only those cases have been discussed so far, which were classifiable with any of the above groups and in which there was a correlation between the results obtained in examination of the patients. The one hundred patients examined, however, included a number of cases that were not classifiable with these groups or in which the findings did not correlate. These patients (extremities) will be discussed under a separate heading.

PATIENTS NOT CLASSIFIABLE WITH ANY OF THE GROUPS

1. Case K. Ten days prior to examination, the popliteal vein and popliteal artery of this woman had been resected for a local malignant tumour, the popliteal artery being replaced by a graft. Al-

though the patient was ambulant, oedema of the leg did not develop. The phlebogram showed normal veins of the leg, absence of a collateral circulation in the region of the knee, in so far as this was identifiable by X-ray and absence of filling of the veins of the thigh.
Venous pressure determination:
S.V.P. 120 = 3 cm. above heart level.
W.V.P. I = II = III : 0.
Apparently, there was an adequate collateral circulation, as the leg did not show any evidence of oedema and the pressure did not increase during walking. The standing venous pressure did not show any increase.

2. Case d. W. concerned a patient who had sustained very severe injuries in the inguinal region, thigh and perineum, associated with extensive damage to the soft tissues, fifteen years prior to examination. These injuries were undoubtedly accompanied by the destruction of veins, in any case of the proximal portion of the saphenous vein. The clinical report at the time did not state anything concerning thrombosis or oedema of the leg in question.

Examination revealed marked varicosis in the region of the short saphenous vein; though the leg did not show any true ulceration, there was a wound that was slow in healing. There was no evidence of the presence of an arterio-venous fistula. The scar in the inguinal region was very tightly stretched and markedly contracted, so that the possibility of compression of the subjacent veins undoubtedly had to be taken into account

Ascending phlebogram: no marked changes in the veins of the leg, retrograde filling of the markedly distended short saphenous vein, a medial incompetent perforator just below the knee. The popliteal and femoral veins did not show any marked post-thrombotic features, although valves were not detectable in these veins. The femoral vein was constricted in the region of the scar.
Venous pressure determination:
S.V.P. = 135 = a few centimetres above heart level.
W.V.P. I = 8; following compression above the knee: 8; following compression below the knee: 11; following compression in the region of the ankle: 22 per cent.

It should be pointed out that the fall in pressure following

elimination of the superficial incompetence was distinctly superior to that produced in most patients with dilated post-thrombotic veins of the thigh, though a considerable proportion of the draining vessels may be assumed to have been absent in this case.

The standing venous pressure did not show any increase.

3. Case d. J., a woman who, as will be apparent from the discussion of the case history on p. 71, caused considerable difficulties.

She had a history of thrombosis two years prior to treatment. The results obtained in phlebography may be summarized as follows: normal deep system of the leg, popliteal vein normal, femoral vein normal as far as half-way the thigh, competent collaterals farther upwards. A markedly distended perforator was present on the medial side of the leg.

Venous pressure determination showed the fall in pressure following elimination of the incompetent perforator to be normal despite post-thrombotic changes in the femoral vein.

PATIENTS IN WHOM THE RESULTS OBTAINED IN CLINICAL AND X-RAY STUDIES DID NOT CORRELATE WITH THOSE OBTAINED IN VENOUS PRESSURE DETERMINATION

1. Case B., a patient who developed relatively acute oedema in both legs from no apparent cause about twelve months prior to being seen by the present author. Besides pitting oedema, examination of the legs did not reveal any other changes. The ascending phlebogram showed slight changes in the deep veins of the right leg, the veins of the thigh and the pelvic veins showing a normal appearance; the phlebogram of the inferior vena cava suggested possible compression in the region of the pancreas, though this could not be verified.

The following levels were recorded in venous pressure determination:

	S.V.P.	W.V.P. I	II	III
right leg:	130	18	12	23
left leg:	160	30	30	30

Accordingly, venous pressure determination produced results which might warrant the conclusion that the development of oedema was attributable to the failure of the venous pump shown to be present.

This failure, however, was not traced to any specific cause. In view of the findings in the patients of group Ib it is doubtful whether compression of the vena cava has any effect on the action of the venous pump.

2. Case v. d. B., a patient affected with thromboangiitis obliterans. The right leg showed unmistakable evidence of impairment of the venous circulation, on clinical examination as well as on examination by X-ray and venous pressure determination (case 1, v. d. B., group VI).

The left leg showed slight pigmentation and incipient induration on the medial surface of the ankle.

The ascending phlebogram of the leg showed slight varicose changes in the muscle veins of the thigh and leg.

In the descending phlebogram, valves were plainly perceptible in the femoral vein.

The following levels were recorded in venous pressure determination: s.v.p.: 151; w.v.p. I: 11, w.v.p. II: 12; w.v.p. III: 9. These are highly pathological findings which are not in accordance with the results obtained in phlebography. For completeness' sake it should be stated that the patient had been treated with left-sided lumbar sympathectomy a few years previously.

3. Case H., a woman, treated at the age of fifty-two. The left foot was crushed when she was four. At the age of thirty-seven, she developed an ulcer below the medial malleolus, which was not due to any apparent cause and has continued to recur ever since.

Examination revealed the presence of an ulcer on the medial surface of the right foot, absence of varices, absence of palpable incompetent perforators, absence of pigmentation, slight induration of the skin about the ulcer, slight oedema. The ankle and foot joints were ankylotic. There was marked atrophy of the leg muscles.

The ascending phlebogram showed a normal deep system and normal saphenous veins provided with valves, a small vascular convolution being present below the ulcerated area.

Venous pressure determination:

s.v.p.: 120 = 4 cm. above heart level.

w.v.p. I = II = III: 20.

This impairment of the action of the venous pump is believed to be due to the atrophy of the muscles of the leg. Naturally, it cannot

be positively stated that the ulcer was the result of venous incompetence.

Comment

In so far as the drawing of conclusions from the results obtained in the examination of a single patient is warranted, the following facts, should be pointed out.

Marked impairment of the action of the venous pump may apparently be present without this impairment being traceable to a specific cause by phlebography. In some cases, this impairment may possibly be attributable to inadequate function of the leg muscles (case H.).

The pressure determination pattern following recent interruption of the popliteal vein alone is found to be similar to that obtained in a post-thrombotic extremity (case K.). The collateral circulation in this region apparently is adequate to the extent that stasis of the flow of blood does not occur. The collaterals were not identifiable by X-ray.

Changes in the upper portion of the femoral vein, like those in the iliac vein, need not cause impairment of the action of the venous pump (case d. J.). This is in accordance with the results obtained in patients d. B. and S. of group II: the fall in pressure was found to be sixty and eighty per cent respectively in these cases, though the superficial femoral vein had been ligated three years and one year prior to examination as treatment for recurrence of ulcer after stripping of the long saphenous vein.

THE INDICATION FOR VENOUS PRESSURE DETERMINATION AND PHLEBGRAPHY

The methods of examination previously described are useful adjuncts in the diagnosis of impairment of the venous circulation. This raises the question of the extent to which this detailed examination is indicated, in other words, whether causal treatment might not be initiated just as well without any knowledge of the changes in function and anatomy of the venous system.

In order to reach a conclusion on the subject, efforts were made to determine whether the results of the present studies might warrant the view that a particular impairment of the circulation

gives rise ulceration. If so, then a detailed pre-operative examination would be unnecessary.

Therefore, the incidence of ulcer of the leg associated with the three following disorders: incompetent perforators, changes in the deep veins of the leg and incompetence of the popliteal and femoral veins, was studied again in the patients examined.

Incompetent perforators

Unmistakable venous ulcers were observed in groups II, III, IV, V, VI and VIII. These groups concerned a total number of eighty-one extremities and forty-one ulcers. X-ray examination failed to reveal the presence of incompetent perforators in groups III, V and VIII. None the less, these groups include a total number of forty-two extremities, twenty-four of which showed ulcers.

The study of the results obtained in venous pressure determination does not give cause for doubting the reliability of the findings in phlebography.

Changes in the deep veins of the leg

The view that the ulcer is due to changes localized solely in the deep veins of the leg has no foundation in fact either. For in groups II and VIII, in which the deep system was normal anatomically and functioned normally, nine ulcers were observed in twenty-three extremities as against eight ulcers in nineteen extremities in groups III and IV in which the changes were solely localized in the veins of the leg.

Incompetence of the popliteal and femoral veins

The presence of incompetence of these veins is not found to be associated with ulcers in every case, whereas ulcers are observed in patients of groups II, III, IV and VIII in which these veins showed a normal appearance in the phlebogram. The fact should be stressed again that the appearance is considered normal when valves have been identified in these veins in the ascending or descending phlebograms. When phlebography was discussed in Chapter I, it was stated that several authors use methods of X-ray examination such as tilt phlebography and dynamic descending phlebography to form an opinion on the competence of the valves visualized.

The present author has had no experience of tilt phlebography. As regards descending phlebography, the fact that one or several valves are passed by contrast medium in a retrograde direction in this method of examination is not believed to warrant the conclusion that these valves are incompetent. This view is supported by the results obtained in venous pressure determination in four cases.

In these cases several valves were passed by the contrast medium in the descending phlebogram made (cf. Fig. III). Venous pressure determination showed that when superficial interference had been eliminated, *the fall in pressure caused by walking was 78, 60, 50 and 55 per cent* respectively. From these findings it is concluded that the veins of the thigh were not incompetent in these cases, so that *the valves visualized were normal.*

In view of the lack of agreement in the literature regarding the interpretation of phlebograms in patients examined for competence of the popliteal and femoral veins, venous pressure determination is of special importance in these cases. Venous pressure determination makes it possible to identify the presence of changes in this region with a fair degree of certainty. An extremity previously affected with thrombosis, as a result of which the popliteal and femoral veins have ceased to function normally, is only found to have a normal venous function in exceptional cases. Without the assistance of the superficial system, walking will not cause any appreciable fall in pressure in this extremity. The present study does not permit the drawing of any conclusions regarding the patency of the popliteal vein: it was not possible sharply to differentiate between the venous pressure determination pattern in cases in which the vein in question was not filled in the ascending phlebogram and that in cases in which filling was obtained, but the vein was incompetent. This naturally may be due to a deficiency of the method employed, as is suggested by the results obtained in the examination of case 9 (S.) of group VI. The popliteal vein was found to be obstructed in this case, the deep femoral vein being normal. Compression of the superficial veins was followed by a rapid rise in pressure during walking. These findings might be expected to be in true keeping with a case of obliteration of the popliteal vein. If a rise in pressure should fail to occur the vein might be assumed to be actually recanalised, though it was not filled in phlebography. However, no rise in pressure was observed

in the patient in whom the popliteal vein had been resected ten days previously. Accordingly, the collateral circulation is assumed to have been inadequate in case S.

The fact that the results obtained in venous pressure determination do not enable any differentiation between an extremity in which the popliteal vein is patent but incompetent and one in which it is not patent, suggests that an incompetent popliteal vein is not an important factor in the return of venous blood from the leg.

To enable the diagnosis of incompetence of the femoral and popliteal veins by venous pressure determination, efforts were made to extend this examination; therefore, the subject examined was requested to strain vigorously when the pressure was at a level normal to the erect position (S.V.P.). The extent to which this resulted in an increase in pressure in the vein of the foot then was recorded. This method of determining the rise in peripheral venous pressure by increasing the intra-abdominal pressure has the drawback that the extent to which the pressure increases varies markedly with the position of the polythene catheter in the vein. When it is slightly tilted or lies in a sharp curve of the vein, the venous pressure will increase very slowly or not at all. (This is not the case when the pressure falls.) The results obtained in this examination therefore were not recorded in a large number of the hundred cases studied: thirty extremities remained; of these, nineteen were post-thrombotic and eleven showed a deep system with valves. Of the post-thrombotic extremities, the popliteal vein was obliterated in two cases.

Results:

no increase in pressure on straining:

2 post-thrombotic extremities in which the popliteal vein was obliterated.

9 extremities showing valves.

increase in pressure:

17 post-thrombotic extremities.

2 extremities showing valves.

This method of examination has been discussed in greater detail, as this test is believed to merit closer attention if conclusive evidence should be provided that excision of deep veins is indicated in certain conditions. In that event, a fixed standard of the pressure exerted by the patient should be developed.

Summarizing, it can therefore be stated that the only correct conclusion regarding the pathogenesis of ulcers of the leg warranted by the present study is, that ulcer of the leg may appear in a wide variety of disturbances of the anatomy and function of the entire venous system of the leg. These disturbances may be present, probably for several decades in some cases, without giving rise to ulceration and even without any marked changes being observed on physical examination of the extremity involved.

The only disorder, the presence of which can be fully accounted for by the results obtained in this examination, is the oedema. Attention should be drawn to the fact that oedema frequently was absent even when severe impairment of the action of the venous pump was observed.

As various surgeons are known to have obtained satisfactory results in the treatment of ulcer of the leg by procedures designed to correct one of the above forms of impairment of the circulation, pre-operative phlebography is believed to be indicated in every case of ulcer of the leg. The extent to which this examination will suffice will be discussed now.

CLINICAL USE OF VENOUS PRESSURE DETERMINATION

The question of the clinical use of venous pressure determination presents itself. In a number of cases, treatment should not be contemplated unless the examination has been completed with phlebography. What is the use of venous pressure determination in deciding which method of treatment is indicated?
It might be of use:

a. as an adjunct to phlebography;
b. as a substitute for phlebography.

a. *Venous pressure determination as an adjunct to phlebography*

In the chapter concerned with phlebography, it was stated that the technique described in this chapter usually produces a readily interpretable X-ray of the deep venous system. In addition, it was stated that in some cases the deep veins are not filled with contrast medium to a sufficient extent to warrant an opinion on the anatomical features of these vessels. This may be the case when a large quantity of contrast medium is lost in the superficial veins or when the deep veins themselves are markedly dilated, so that the contrast medium is too strongly diluted. It may also happen

that the veins of the foot are considerably dilated and that prolonged stagnation of the contrast medium occurs in these veins, which prevents it from flowing proximalwards in a sufficient concentration.

Accordingly, the data obtained on the changes in the venous system may be inadequate despite phlebography.

As a rule, it will be possible to draw conclusions from the few data available without another examination being necessary, though on the other hand, indications may be based on mistakenly drawn conclusions despite the fact that another examination is made. This is illustrated in the following case history:

d. J., a 31-year-old woman.

Thrombosis of the left leg following a gynaecological operation performed in 1956.

In 1958, the patient was treated for a pathological condition of the left leg which showed oedema, pigmentation and induration medial to and above the ankle.

Phlebography was performed. The ascending phlebogram showed almost complete absence of filling of the deep veins of the leg, the contrast medium leaving the deep system through a perforator and flowing proximalwards through the dilated superficial system.

The descending phlebogram showed post-thrombotic changes in the veins of the thigh.

After ascending phlebography had been performed again and failed to produce any fresh points of view, it was decided to strip the markedly varicose long saphenous vein and to ligate the incompetent perforator.

Follow-up treatment consisted in having the patient wear an elastic stocking.

Things went well until 1959, when the patient, being affected with typhoid fever had a recurrence of thrombosis.

In March 1960, the appearance of the left leg was similar to that observed eighteen months previously.

This time, the venous pressure was determined.

Surprisingly, the following results were obtained:

S.V.P.: 130
W.V.P. I: 22
W.V.P. II: 22
W.V.P. III: 64

With the exception of a few diffusely distended superficial veins and another markedly dilated perforator, the ascending phlebogram, made with the aid of a better technique than that previously used, did not show any changes in the leg. The popliteal veins as well as the distal portion of the superficial femoral vein were normal. The femoral vein was obliterated in the upper half of the thigh and collaterals showing a normal appearance were present in this region.

In other words, the phlebogram made eighteen months previously had been misleading. Despite the post-thrombotic changes in the upper portion of the femoral vein, the function of the veins was normal following elimination of the incompetent perforators in the region of the ankle.

At the time of writing, marked improvement has occurred after ligation of the medial perforators using the method as suggested bij Linton in 1938.

This naturally is merely one instance, but it is not an isolated case. In this patient, the incorrect interpretation of the phlebogram did not have any disastrous effects, but there have been cases in which venous pressure determination was the decisive factor, so that distressing results due to misinterpretation of the X-ray picture were prevented. This is particularly liable to occur when phlebography is performed with a view to determining whether or not the deep venous system is patent. In performing phlebography, several authors have only this object in view, the superficial veins being considered superfluous when the deep system is patent. They believe the changes in the post-thrombotic leg, particularly ulceration, to be due to impairment of the superficial circulation and report having obtained satisfactory results in every case in which 'varicose' superficial veins were eliminated.

Phlebography fails when the rôle played by the superficial veins in post-thrombotic legs has to be identified (cf. Figs I and II). Which are the data provided on the subject by venous pressure determination?

Elimination of varicose superficial veins was constantly found to produce a noticeable improvement in the action of the venous pump in patients who had not had thrombosis. What were the findings in the two post-thrombotic groups V and VI?

The data obtained in examination of these patients include varicosis in twenty-three cases. Compression of the superficial veins below the knee, however, had a beneficial effect in four cases only. Compression was ineffective in nine cases and even had an adverse effect in ten cases.

Therefore, the fact that examination suggests that a vein is varicose in view of its tortuous course and dilatation, does not warrant the conclusion that this vein is not an important factor in the circulation. Interpretation of the results of Trendelenburg's test frequently is impossible in these veins which hardly collapse as a result of their thick walls and which, moreover, are rapidly filled from a distal direction. Moore (1955) reports the case of a patient showing a superficial system of this type, who developed superficial phlebitis after phlebography. This was immediately followed by oedema of the leg.

In some patients of group VI, i.e. those in whom perforators were present, the fall in pressure produced by elimination of the perforator in relation to the region distal to the latter was remarkably satisfactory for a post-thrombotic leg. This may possibly be accounted for as follows: Bauer (1942) showed that the superficial system is an important factor in the return of venous blood from the leg during the acute stage of thrombosis. The blood from the deep veins reaches the superficial veins by retrograde flow through the perforators. At a later stage a deep collateral circulation will develop, though as was shown in a number of the above cases, the superficial system continues to play an important rôle. However, the 'supplying' perforator apparently has a local injurious effect as a result of the intermittent rise in pressure during contractions of the calf muscles. This local injurious effect is occasionally detectable by venous pressure determination, like it is in group II, when the transmission of pressure to the veins of the foot is interrupted. The perforator is situated above the tourniquet applied for this purpose, so that the blood drained by the calf muscles can freely flow proximalwards through this vessel without this having an injurious effect in a distal direction.

The difference with group II is that in the latter the superficial system has an adverse effect on the action of the venous pump, whereas the deep system functions adequately. In other words, the fall in pressure following compression in the region of

the ankle is a criterion of the function of the deep veins in group II and provides a criterion of the combined function of the deep and superficial systems in group VI. When compression of the superficial veins in the region of the knee has previously been found to have an adverse effect, this warrants the conclusion that the value listed under W.V.P. III mainly reflects the function of the superficial veins.

This is illustrated in the findings in a number of patients of group VI.

Case	S.V.P.	W.V.P. I	II	III
G.	139	4	0	7
K.	139	6	0	6
K.	142	13	0	21
v. d. L.	130	12	10	23
d. W.	132	19	9	35

The above findings are believed to warrant the conclusion that elimination of the superficial veins is indicated in post-thrombotic legs in exceptional cases only.

Prior to deciding upon elimination of superficial veins in patients with 'post-thrombotic' extremities, the surgeon should determine the venous pressure.

Naturally, sole ligation of a perforator in a post-thrombotic leg will initially have the effect that the venous blood flows less readily from the deep to the superficial system, but experience shows (cf. the data as reported by Dodd and Cockett, 1955) that this does not give rise to severe disturbances, as collaterals ensuring this communication apparently develop in every case.

Accordingly, an important venous communication is ligated because its injurious effect is regarded as a factor of greater importance than its function as a draining vessel. *This procedure is comparable with excision of the popliteal vein in which the same thing is in fact done.*

b. *Venous pressure determination as a substitute for ascending phlebography*

Every physician should try to reduce to a minimum the exposure of his patients to radiation. This does not mean that phlebography should not be done when it is considered indicated, but that the indications should be restricted. The more so, as the contrast mediums employed have been shown to have injurious effects on the wall of the vessels (Zinner and Gottlob, 1959).

In which cases can venous pressure determination be substituted for phlebography?

1. In those cases in which phlebography is only performed with a view to excluding changes in the venous system. When the levels recorded in venous pressure determination are normal, phlebography will be unnecessary. This will be the case with patients showing oedema and other disturbances which might possibly be due to changes in the venous system.

2. On p. 61 it was shown that patients can be classified with one of the groups described on the basis of the results obtained in venous pressure determination. This renders phlebography unnecessary in a number of cases; for instance, in those cases in which the examination is only made in order to be able positively to rule out a disturbance of the deep veins.

Certain surgeons believe that the results obtained in the surgical treatment of patients with post-thrombotic changes in the deep veins are not sufficiently good to justify a preference for this form of treatment to conservative therapy. Conversely, there are certain adherents of conservative treatment who take the view that surgical treatment may be useful in cases in which the deep system functions satisfactorily. In the opinion of the present author, venous pressure determination will provide the ideal method of examination for these two groups. When application of a tourniquet below the knee results in a fall in pressure which can be considered normal or when this occurs following compression in the region of the ankle, the function of the deep system may be assumed to be unimpaired.

c. *Venous pressure determination as a substitute for descending phlebography*

In some cases the ascending phlebogram will not afford a sufficiently positive indication of the extent to which the veins of the thigh are affected. E.g., in those cases in which the veins of the leg show diffuse changes, whereas the localization of the popliteal and femoral veins is normal, but valves are not identifiable in these veins. In that case, a descending phlebogram will have to be made.

When the fall in venous pressure recorded in those cases is over 25 per cent, descending phlebography will be unnecessary.

SUMMARY

The results obtained in phlebography in over 250 cases have convinced the present author that markedly different changes in the anatomy of the venous system of the entire leg may produce identical clinical pictures. Oedema, pigmentation showing a specific localization, induration of the skin and subcutaneous tissue, ulcer of the leg and pain in the calf may occur in various combinations in patients with incompetence of one of the saphenous veins. These complications are most common, however, in the three following forms of impairment of the venous circulation.

1. More or less severe varicosis of one of the saphenous veins complicated by incompetence of perforators on the medial side of the leg, the deep venous system of the leg showing a normal appearance in the phlebogram.

2. Varicosis of a saphenous vein, the phlebogram showing diffuse changes in the deep veins of the leg whether or not accompanied by incompetence of perforators.

3. Post-thrombotic changes in all deep veins of the leg and thigh whether or not associated with incompetence of perforators.

As a rule, the fact that three markedly different conditions may give rise to similar changes in the leg is apparently overlooked by authors engaged in studying the pathogenesis of the leg ulcer. Those who do pay attention to this fact apparently assume that though the changes are different anatomically, the impairment of function of the venous system is identical.

The present study was designed to determine whether there is a correlation between the changes in the venous system identifiable by X-ray and the accompanying impairment of function.

Chapter I is concerned with phlebography.
The value of the method and the questions to be answered in making the examination are reviewed and the interpretation of the phlebograms is discussed. The chapter concludes with a discussion of the technique, based on the literature on the subject.

Chapter II is concerned with venous pressure determination. The present author having stated his opinion that the function of the venous system may be determined by measuring the venous pressure after walking, the literature on the subject is reviewed. It is shown that theoretically it should be possible to differentiate between the various forms of impairment of the venous circulation with the aid of venous pressure determination.

The investigations proper are described in Chapter III.

PHLEBOGRAPHY was performed and the venous pressure determined in 100 extremities.

The technique adopted is described.

Ascending phlebogram

Erect position (65°)

Venesection on the upper surface of the foot, polythene catheter.

Tourniquet about the ankle, leg bandaged.

Thirty ml. of contrast medium injected within one minute.

Fluoroscopy and stereoscopic exposures.

Movements of the foot when the leg is filled with contrast medium.

Valsalva's manoeuvre is performed when the femoral and popliteal veins are filled.

Descending phlebogram

Erect position (65°)

Venesection, polythene catheter through long saphenous vein into femoral vein.

Valsalva's manoeuvre is performed immediately after contrast medium has been observed in the femoral vein.

The VENOUS PRESSURE is measured by the following method.

The pressure is determined in a vein running between the first and second metatarsals, which vein is connected by a polythene catheter with a graduated glass tube filled with physiological saline solution. The following levels are recorded.

S.V.P. The pressure, measured in cm. of water, after the patient has been standing motionless until variations in the fluid level have ceased to occur.

W.V.P. I. The fall in pressure, expressed in percentages of the S.V.P. following the performance of walking movements which are continued until the pressure ceases to fall.

W.V.P. II. Idem, though in this case the superficial veins are compressed by a rubber tube below the knee.

W.V.P. III. Idem, though in this case a rubber tube is applied about the ankle, which measure is designed to eliminate the effect of leakage through incompetent perforators on the venous pressure in the veins of the foot.

In the present study, it was essential to compare the three last-named readings.

The extremities were classified into eight groups, this classification being based on the results obtained in physical examination and phlebography.

Group Ia. Venous system normal throughout the entire leg.
Group Ib. Idem, though changes were detectable in the region of the iliac vein.
Group II. Normal deep system with incompetent perforators.
Group III. Changes in the deep veins of the leg, absence of incompetent perforators.
Group IV. Idem, but presence of incompetent perforators.
Group V. Post-thrombotic changes throughout the entire leg, incompetence of popliteal and femoral veins, absence of incompetent perforators.
Group VI. Idem, but presence of incompetent perforators.
Group VII. Normal venous system, lymphoedema.
Group VIII. Primary varicosis without incompetence of perforators, absence of changes in the phlebogram.

The clinical pictures shown by the patients of groups II, III, IV, V and VI were found to bear a marked resemblance to one another.

Results of the examination

In patients not showing venous disorders, the fall in pressure produced by walking was more than fifty per cent of the S.V.P. with or without application of a tourniquet. Post-traumatic or post-thrombotic changes in the region of the iliac vein (group Ib) were not found to affect the function of the venous system of the leg in question. Patients with varices unaccompanied by incompetent perforators or changes in the deep veins (group VIII) usually did not show any severe impairment of function, the W.V.P. II was normal in every case and did not differ from the W.V.P. III.

When incompetent perforators were visualised in the phlebogram, however, this was associated with severe impairment of

function in most cases; compression of the saphenous vein below the knee failed to produce a normal fall in pressure; the W.V.P. III, however, was normal in every case (group II). As soon as the phlebogram showed changes in the deep veins of the leg, which occurred in twenty per cent of the cases, walking never resulted in a normal fall in pressure; the fall in W.V.P. III was about thirty-five per cent of the S.V.P. in these cases (groups III and IV). When the changes in the deep veins extended as far as the thigh (groups V and VI), walking failed to produce an appreciable fall in pressure in the greater part of the cases. Compression of the superficial veins at any level produced a change for the worse rather than an improvement in these cases. Compression below incompetent perforators (present in fifty per cent of the post-thrombotic patients) only resulted in improvement in exceptional cases.

These studies are believed to warrant the conclusion that there is an unmistakable correlation between the results obtained in physical examination and phlebography on the one hand and those obtained in venous pressure determination on the other. Moreover, venous pressure readings usually enabled the classification of the patient with one of the groups described.

The discussion of a number of cases showed that there are exceptions to these rules.

The question whether the data obtained in these studies warrant any conclusion regarding the pathogenesis of ulcer of the leg is discussed. It is the belief of the present author that the ulcer cannot be attributed to a particular disorder, so that it is not likely that just a single form of surgical treatment will be indicated in ulcer of the leg. Surgical treatment of leg ulcers therefore is not believed to be justifiable unless a pre-operative examination of the types described has been made.

The clinical use of venous pressure determination is reviewed. In some cases, this procedure may serve as a substitute for phlebography; occasionally, phlebography will have to be completed by venous pressure determination.

In addition, the following conclusions may be drawn from these studies.

Elimination of superficial veins in post-thrombotic extremities can be expected to be useful in exceptional cases only.

The fact that a number of valves in the femoral vein are passed by contrast medium in a retrograde direction in the dynamic descending phlebogram does not warrant the conclusion that this vein is incompetent.

Venous pressure determination does not enable any differentiation between an obliterated and an incompetent popliteal vein. In every case in which valves are present, however, the fall in pressure will be markedly superior to that observed when valves are absent.

SAMENVATTING

Het flebografisch onderzoek van meer dan 250 patiënten heeft ons de overtuiging gegeven, dat afwijkingen in de anatomie van het veneuze stelsel van het gehele been, van totaal verschillende aard, aanleiding kunnen geven tot het ontstaan van hetzelfde klinische beeld. Oedeem, pigmentaties met specifieke localisatie, induratie van huid en subcutis, ulcera cruris en kuitpijn, in verschillende combinaties, kunnen optreden bij patienten met insufficiëntie van een der vv. saphenae. Het meest frequent echter zien wij deze complicaties bij de drie volgende stoornissen in de veneuze circulatie.

1. Min of meer ernstige varicosis van een der vv. saphenae, gecompliceerd door insufficiëntie van perforerende venen aan de mediale zijde van het onderbeen, bij een röntgenologisch normaal diep systeem.

2. Varicosis van een v. saphena; op het flebogram verspreide afwijkingen in de diepe venen van het onderbeen, met of zonder insufficiëntie van perforerende venen.

3. Posttrombotische afwijkingen in alle diepe venen van onder- en bovenbeen, met of zonder insufficiëntie van perforerende venen.

De schrijvers, die zich bezighouden met de etiologie van het ulcus cruris, schijnen over het algemeen dit feit over het hoofd te zien, dat dus drie, anatomisch althans, geheel verschillende toestanden kunnen leiden tot dezelfde afwijkingen aan het onderbeen. Degenen die hieraan wel aandacht besteden schijnen aan te nemen, dat bij deze toestanden dan wellicht anatomisch verschillende afwijkingen bestaan, doch dat de stoornis in de functie van het veneuze stelsel steeds dezelfde is.

Wij hebben ons bij ons onderzoek ten doel gesteld na te gaan of er een correlatie bestaat tussen de röntgenologisch aantoonbare afwijkingen in het veneuze stelsel en de hierbij bestaande stoornis in de functie.

Hoofdstuk I behandelt de flebografie. Besproken worden de waarde en de vraagstelling van het onderzoek, benevens de interpretatie van de verkregen beelden. Tenslotte wordt aan de hand van de litteratuur die op dit gebied bestaat ingegaan op de techniek.

In hoofdstuk II wordt de veneuze drukmeting behandeld. Nadat wij als onze mening te kennen hebben gegeven, dat de functie van het veneuze stelsel kan worden beoordeeld door het meten van de veneuze druk na lopen, worden mededelingen gedaan over de op dit gebied bestaande litteratuur. Op theoretische gronden wordt aangetoond, dat de mogelijkheid moet bestaan om d.m.v. de drukmeting de verschillende stoornissen in de veneuze circulatie van elkaar te onderscheiden.

In Hoofdstuk III wordt het eigenlijke onderzoek beschreven. Bij 100 extremiteiten werden een flebografisch onderzoek en een veneuze drukmeting verricht.

De door ons toegepaste techniek wordt beschreven.

Ascenderend flebogram

Staande houding (65°).

Venasectie op de voetrug, polythene-catheter.

Stuwband om de enkel, zwachtelen van het onderbeen.

30 cc. contrastmiddel, injectie in één minuut.

Doorlichting en stereoscopische opnamen.

Voetbewegingen wanneer het onderbeen met contrast gevuld is.

Valsalva wanneer de vv. femoralis en poplitea gevuld zijn.

Descenderend flebogram

Staande houding (65°).

Venasectie, polythene-catheter via v. saphena magna in v. femoralis.

Valsalva direkt nadat contrast in de v. femoralis is gezien.

De *veneuze drukmeting* voeren wij uit op de volgende wijze.

Meting in een vene tussen de metatarsalia I en II, die d.m.v. een polythene-catheter wordt verbonden met een glazen stijgbuis, gevuld met fysiologische zoutsolutie. Registratie van de volgende waarnemingen.

s.v.p. Druk, gemeten in cm water, nadat de patiënt zolang heeft stilgestaan, dat geen schommelingen in de vloeistofspiegel meer optreden.

w.v.p. 1 Daling van de druk, uitgedrukt in percenten van

s.v.p., na het maken van loopbewegingen voortgezet tot de druk ophoudt te dalen.

w.v.p. II id. doch met compressie van de oppervlakkige venen met een rubberslang, onder de knie.

w.v.p. III id. doch met een rubberslang om de enkel, waarmee wij beogen het effekt van de lekkage via insufficiënte perforerende venen op de veneuze druk in de voetvenen uit te schakelen.

Essentieel was bij ons onderzoek het vergelijken van de drie laatste waarnemingen.

Op grond van de bevindingen bij fysisch en röntgenologisch onderzoek werden de extremiteiten ingedeeld in een achttal groepen.

Groep Ia. Normaal veneus stelsel van het gehele been.
Ib. id. doch met afwijkingen in het gebied van de v. iliaca.
II. Normaal diep systeem, met insufficiënte perforerende venen.
III. Afwijkingen in de diepe venen van het onderbeen, geen insufficiënte perforerende venen.
IV. id. doch mèt insufficiënte perforerende venen.
V. Posttrombotische veranderingen in het gehele been, insufficiëntie van de vv. poplitea en femoralis, geen insufficiëntie van perforerende venen.
VI. id. doch mèt insufficiëntie van perforerende venen.
VII. Normaal veneus stelsel, lymphoedeem.
VIII. Primaire varicosis zonder insufficiëntie van perforerende venen, zonder afwijkingen op het flebogram.

Het klinische beeld van de patienten uit de groepen II, III, IV, V en VI bleek sterk overeen te komen.

Resultaten van het onderzoek

Bij de patiënten zonder afwijkingen in het veneuze stelsel bedroeg de drukdaling door lopen meer dan 50 % van s.v.p., met of zonder stuwband. Afwijkingen in het gebied van de v. iliaca, hetzij van posttraumatische of posttrombotische aard, (groep Ib), bleken geen invloed te hebben op de functie van het veneuze stelsel van het betreffende been. Bij de patiënten met varices zonder insufficiënte perforerende venen en zonder afwijkingen in de diepe venen

(groep VIII) bestond over het algemeen geen ernstige functiestoornis, W.V.P. II was steeds normaal en verschilde niet van W.V.P. III.

Indien op het flebogram wel insufficiënte perforerende venen waren aangetoond, bestond er steeds een ernstiger stoornis in de functie; compressie van de v. saphena onder de knie bracht weinig verbetering, W.V.P. III was echter in alle gevallen normaal. (groep II). Zodra het flebogram afwijkingen in de diepe onderbeensvenen toonde, hetgeen bij 20 % van de patiënten het geval was, werd door lopen geen normale drukdaling bereikt; de daling bij W.V.P. III bedroeg hier ongeveer 35 % van S.V.P. (groepen III en IV). Indien de afwijkingen in de diepe venen zich uitstrekten tot het bovenbeen (groepen V en VI) werd door lopen in de meeste gevallen geen drukdaling van betekenis verkregen. Compressie van de oppervlakkige venen, op welk niveau dan ook, had hier eerder een verslechtering dan een verbetering tot gevolg. Slechts bij uitzondering resulteerde compressie onder insufficiënte perforerende venen (aanwezig bij 50 % van de posttrombotische patiënten) in een verbetering.

Wij menen uit dit onderzoek te mogen concluderen, dat er een onmiskenbare correlatie bestaat tussen de bevindingen van het fysisch en röntgenologisch onderzoek enerzijds en de gegevens verkregen bij de veneuze drukmeting anderzijds. Tevens is gebleken, dat uit de waarnemingen bij de drukmeting gewoonlijk kan worden geconcludeerd tot welke van de genoemde groepen de patiënt behoort.

Op deze regels blijken uitzonderingen te bestaan. Dit wordt gedemonstreerd aan de hand van de bespreking van enige patiënten.

Vervolgens wordt nagegaan, of op grond van de bij dit onderzoek verkregen gegevens enige conclusie kan worden getrokken omtrent de etiologie van het ulcus cruris. Wij geven als onze mening te kennen, dat niet één bepaalde afwijking aansprakelijk kan worden gesteld voor het ontstaan van het ulcus, dus dat het niet aannemelijk is, dat er slechts één operatieve behandeling voor het ulcus bestaat. Op grond hiervan menen wij, dat operatieve therapie bij het ulcus cruris niet verantwoord is zonder voorafgaand onderzoek in de door ons bedoelde zin.

Tenslotte wordt de klinische betekenis van de veneuze drukmeting

besproken. Dit onderzoek kan in bepaalde gevallen de flebografie vervangen, terwijl het soms noodzakelijk zal blijken te zijn de flebografie aan te vullen met een drukmeting.

Uit de door ons verrichte onderzoekingen kunnen verder nog de volgende conclusies worden getrokken.

Van het elimineren van oppervlakkige venen is bij posttrombotische extremiteiten slechts bij uitzondering succes te verwachten.

Uit het feit, dat op het dynamisch descenderend flebogram een aantal kleppen in de v. femoralis door contraststof in retrograde richting wordt gepasseerd mag niet de conclusie worden getrokken, dat deze vene insufficiënt is.

Met de drukmeting blijkt geen verschil te kunnen worden vastgesteld tussen een geoblitereerde en een insufficiënte v. poplitea. Indien kleppen in de v. poplitea aanwezig zijn, is de drukdaling steeds aanzienlijk beter dan wanneer dit niet het geval is.

RÉSUMÉ

L'examen phlébographique chez plus de 250 patients nous a montré que les anomalies anatomiques du système veineux du membre inférieur sont très variées, mais peuvent se manifester sous le même syndrome clinique. Ce syndrome est caractérisé soit par un, soit par la combinaison de plusieurs des symptômes suivants: oedème, pigmentation à localisation spécifique, induration de la peau ou du tissu sous-cutané, ulcera cruris et douleurs du mollet. Dans la majorité des cas nous trouvons ces symptômes dans les trois troubles suivants de la circulation veineuse du membre inférieur.

1. État variqueux plus ou moins grave d'une des veines saphènes, associé à une insuffisance d'une ou de plusieurs veines perforantes du mollet; sur le phlébogramme système veineux profond normal.

2. État variqueux d'une des veines saphènes avec anomalies diffuses du système veineux profond, associé ou non associé à une insuffisance des veines perforantes.

3. Anomalies anatomiques postthrombotiques diffuses et variées de toutes les veines profondes, avec ou sans insuffisance des veines perforantes.

En général, les auteurs qui s'occupent de l'étiologie de l'ulcus cruris, méconnaissent que le même aspect clinique peut être causé par des anomalies anatomiques très différentes. D'autres admettent des anomalies anatomiques différentes, mais pensent que le dérèglement de la pompe veineuse est toujours le même.

La mesure de la pression veineuse chez 100 malades nous a enseigné que le dérèglement de la pompe veineuse est totalement différent suivant les anomalies anatomiques du système veineux.

Nous mesurons la pression veineuse de la façon suivante. Un tube de polythène est placé dans une veine du dos du pied, entre les os métatarsiens I et II. Ce tube est mis en connection avec un tube de verre calibré, rempli d'une solution physiologique.

Nous enrégistrons ensuite les pressions suivantes.

s.v.p. Pression veineuse en cm H_2O, station debout immobile.

W.V.P. I. Baisse de la pression veineuse, exprimée en pourcentage de la pression debout (S.V.P.), en ambulation sur place jusqu'à l'arrêt de la baisse de la pression.

W.V.P. II. Idem, mais avec compression des veines superficielles au-dessous du genou. (garrot)

W.V.P. III. Idem, mais garrot autour de la cheville, pour éliminer l'effet de la fuite du sang par les veines perforantes insuffisantes vers le pied.

Ce qui importe, c'est la comparaison de ces trois dernières mensurations.

Résultats

Chez les patients normaux, la baisse de la pression veineuse en ambulation sur place dépasse 50 % de la pression en station debout immobile (S.V.P.), avec ou sans garrot.

Chez les patients porteurs de varices, sans insuffisance des veines perforantes et sans anomalies des veines profondes (phlébogramme), la fonction de la pompe veineuse est en général peut perturbée, en W.V.P. II toujours baisse normale, égale à celle de W.V.P. III.

Si des veines perforantes insuffisantes étaient visibles sur le phlébogramme, le dysfonctionnement de la pompe veineuse était toujours plus important, peu d'amélioration par compression de la saphène au-dessous du genou, mais dans tous les cas W.V.P. III montrait une valeur normale.

Dans tous les cas, où sur le phlébogramme on constatait des anomalies anatomiques des veines profondes au-dessous du genou (dans 20 % des cas) une baisse normale n'était pas obtenue. La baisse variait autour 35 % en W.V.P. III. Si le phlébogramme montrait des changements pathologiques dans les veines profondes du mollet et dans les veines poplitée et fémorale, la baisse de la pression veineuse était pratiquement nulle. La compression de la cheville, donc au-dessous des veines perforantes insuffisantes, visibles sur le phlébogramme seulement dans 50 % des ces cas postthrombotiques, donnait lieu dans quelques cas à une amélioration.

En outre, nous avons fait les observations suivantes. Baisse négligeable ou absente dans tous les cas où sur le phlébogramme descendant dynamique les veines poplitée et fémorale ne montraient pas de valvules. Aucune différence dans la baisse de la pression chez les patients avec une poplitée large, mais sans val-

vules, et chez ceux avec une poplitée oblitérée. En cas de présence de valvules dans les veines poplitée et fémorale la baisse de la pression veineuse est toujours plus importante qu'en cas d'absence de valvules. Le fait que la substance de contraste dépasse des valvules sur le phlébogramme descendent dynamique ne veut pas dire que ces veines soient insuffisantes.

Un changement pathologique au niveau de la veine iliaque, du genre postthrombotique ou traumatique n'influence pas le fonctionnement des veines du membre inférieur.

De l'ensemble de nos recherches nous avons tiré les conclusions suivantes.

A part de quelques rares exceptions, il y a une correlation réciproque entre les résultats des phlébogrammes et de la mesure de la pression veineuse.

Vu que plusieurs anomalies anatomiques du système veineux peuvent donner lieu à un ulcus cruris, il est évident que le traitement chirurgical de l'ulcus est différent suivant l'anomalie anatomique.

La suppression des veines superficielles des membres inférieurs postthrombotiques n'est que très rarement indiquée.

La phlébographie doit rester une méthode pour nous orienter sur l'anatomie des veines et non sur leur fonctionnement. La mesure de la pression veineuse peut dans certain cas remplacer la phlébographie, ou la compléter.

TECHNIQUE DE LA PHLÉBOGRAPHIE

Phlebographie ascendante

Patient en position debout, légèrement incliné en arrière (65°).
Dénudation d'une veine dorsale du pied et introduction d'un tube de polythène. Garrot autour de la cheville, bandage du mollet.
Injection de 30 cc. de substance de contraste. Temps d'injection une minute. Scopie et photos stéreoscopiques.
Mouvement du pied après remplissage des veines du mollet.
Effort de Valsalva après remplissage des veines poplitée et fémorale.

Phlebographie descendente dynamique

Même position du patient.
Introduction de tube de polythène dans la veine fémorale par la veine saphène interne.
Effort de Valsalva dès l'apparition de la substance de contraste dans le veine fémorale.

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I and II

Ascending phlebogram made in a woman having had thrombosis of the right leg in 1949. In 1953, an ulcer appeared on the medial surface of the ankle. The phlebograms were made in 1953 and 1960 respectively.

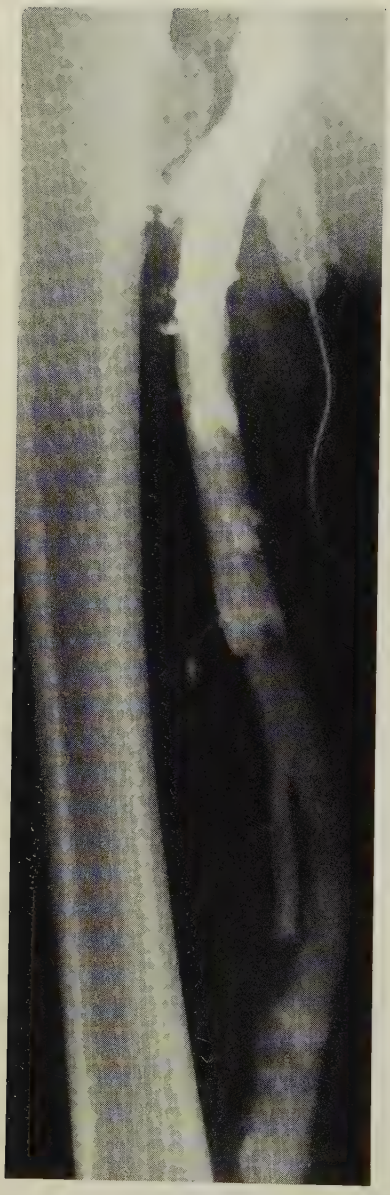
The phlebogram shown in Fig. I was taken in the recumbent position, the contrast medium being injected by intraosseous route (medial malleolus). Filling is confined to the superficial veins in which valves are plainly perceptible, the veins also showing an otherwise normal appearance.

The phlebogram shown in Fig. II was made using the method described. Filling of a large number of tortuous valveless deep veins in the leg and the region of the popliteal vein is plainly perceptible.

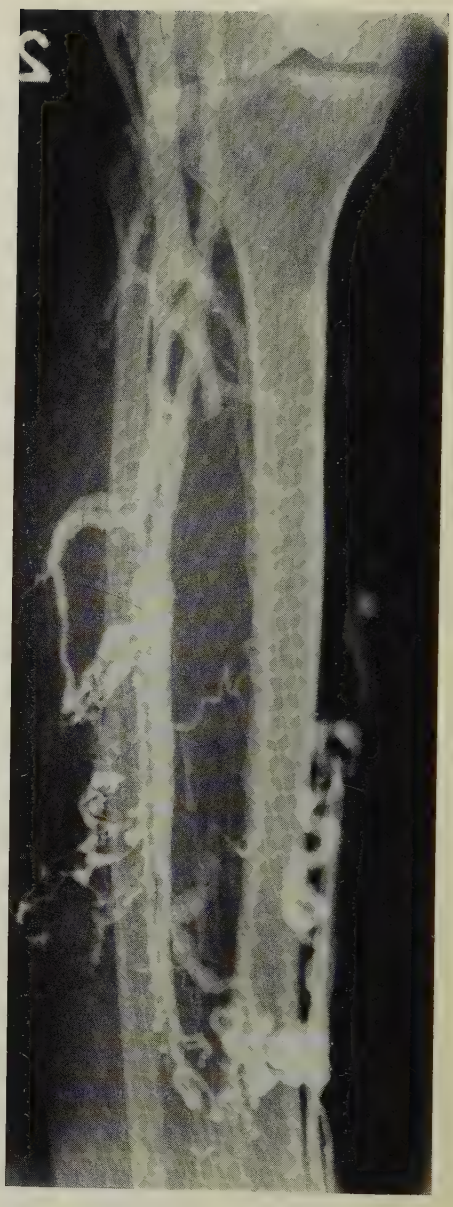
The different appearance of the same region in these two phlebograms might be attributable to the fact that recanalization of the deep veins occurred in the period from 1953 to 1960; in the opinion of the present author, however, the difference is largely due to a difference of technique.

In 1958, an operation was performed upon the superficial veins in another hospital without pre-operative phlebography, the saphenous vein being ligated (stripped?) and perforators being ligated. In view of the phlebogram taken in 1953, the effectiveness of this procedure is open to doubt.

Venous pressure determination in 1960: S.V.P.: 133 W.V.P. I: 27, W.V.P. II: 22, W.V.P. III: 17.



III



IV

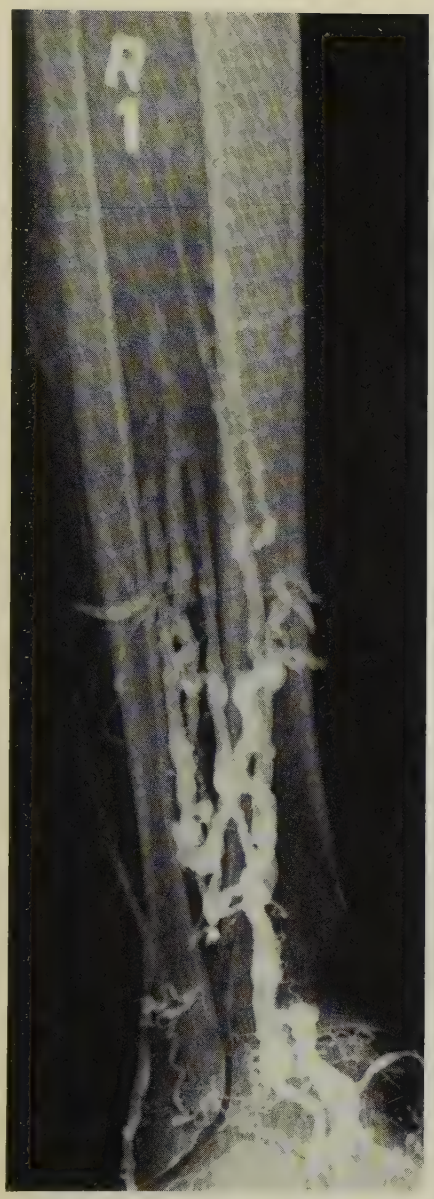
III. *Descending phlebogram.* Valves are plainly perceptible in the femoral vein. The contrast medium passes these valves in a retrograde direction. A patient with primary varicosis, not showing any changes in the deep veins of the leg.

On venous pressure determination, W.V.P. III was found to be 60 per cent, which shows that the function of the deep veins was normal.

IV. *Ascending phlebogram.* Patient of group IV. Changes in the deep veins of the leg; obstruction and collaterals following a tortuous course; incompetent perforator on the medial side and superficial varicosis; popliteal vein normal.

Venous pressure determination:

S.V.P.: 129, W.V.P. I: 12, W.V.P. II: 20, W.V.P. III: 40.



V

VI

V. *Ascending phlebogram.* Patient of group VI. Partial obstruction in the deep veins of the leg, the veins being valveless and following a tortuous course; incompetent perforator on the medial side near the ankle. For further details, cf. Fig. VII.

VI. *Ascending phlebogram.* Patient of group IV. Valves are plainly perceptible in the greater part of the deep veins. There is a markedly distended muscle vein following an abnormal course and communicating with the superficial system which is varicose as well.

Venous pressure determination:

S.V.P.: 147, W.V.P. I: 16, W.V.P. II: 28, W.V.P. III: 43.

VII

VIII

VII. *Ascending phlebogram.* Same case as that of Fig. V. Recanalization and collateral circulation in the region of the popliteal and femoral veins.

Venous pressure determination:

S.V.P.: 148, W.V.P. I: 0, W.V.P. II: 8, W.V.P. III: 20.

VIII. *Ascending phlebogram.* Patient of group V. Deep veins showing valves and following a normal course as well as a few normal muscle veins in the lower third of the leg. Absence of incompetent perforators.

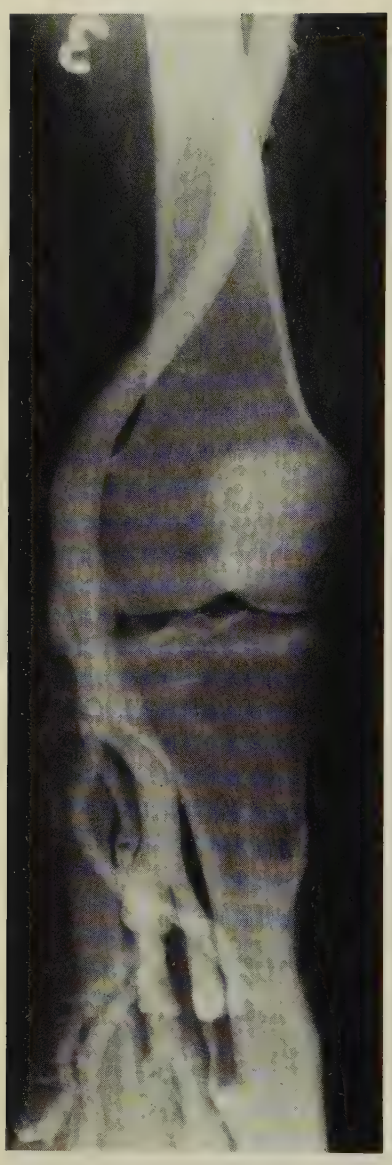
The veins in the upper two-thirds of the leg are characterized by partial obstruction, a tortuous course and absence of valves, recanalization of the popliteal vein. Venous pressure determination:

S.V.P.: 131, W.V.P. I: 22, W.V.P. II: 12, W.V.P. III: 0.

IX and X

Ascending phlebogram. Patient of group V. The leg shows a large number of constricted deep valveless veins following an abnormal course, absence of incompetent perforators. Recanalization of popliteal and femoral veins and development of collaterals. Venous pressure determination:

S.V.P.: 122, W.V.P. I: 0, W.V.P. II: 0, W.V.P. III: 0.



XV

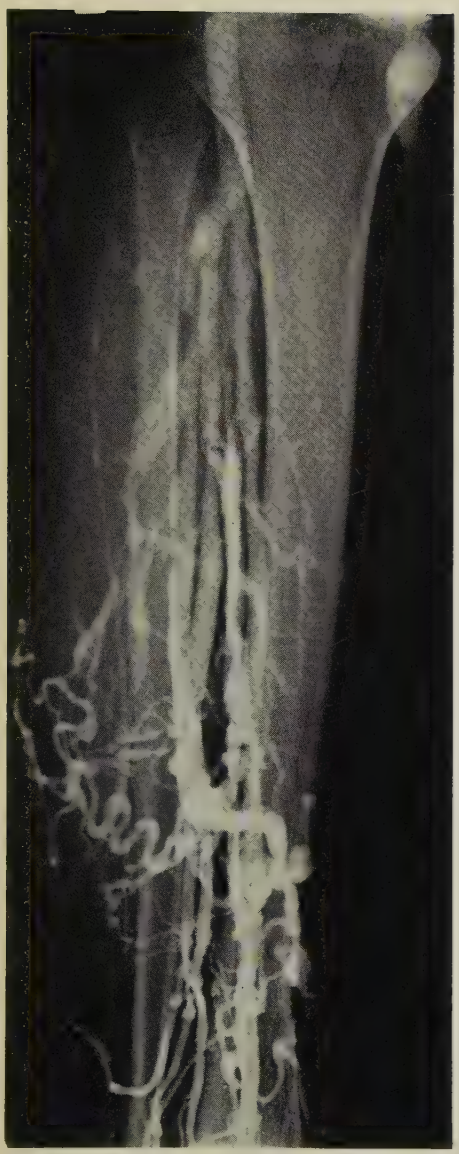
XVI

XV. *Ascending phlebogram.* Normal appearance of popliteal vein. Despite straining by the subject examined, valves are not perceptible in the popliteal and femoral veins.

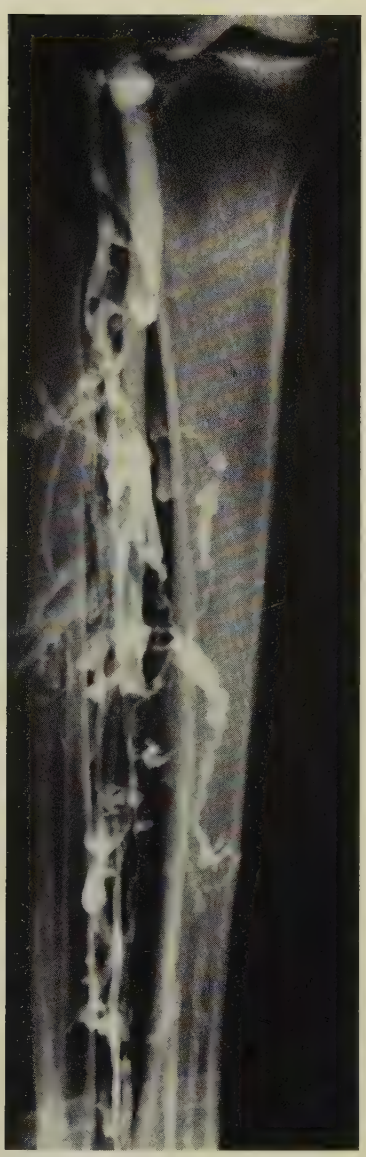
XVI. *Decsending phlebogram.* Normal appearance, valves plainly perceptible in the superficial and deep femoral veins, above which contrast medium has accumulated, though contrast medium also passes the valves in a retrograde direction.

Venous pressure determination:

S.V.P.: 129, W.V.P. I: 50, W.V.P. II: 75, W.V.P. III: 78.



XVII



XVIII

XVII. *Ascending phlebogram.* Patient of group IV. The greater part of the deep system of the leg is normal, valves being perceptible in most large veins. A markedly distended perforator, communicating with a tortuous dilated deep vein, is present on the medial side. Superficial varicosis is perceptible as well.

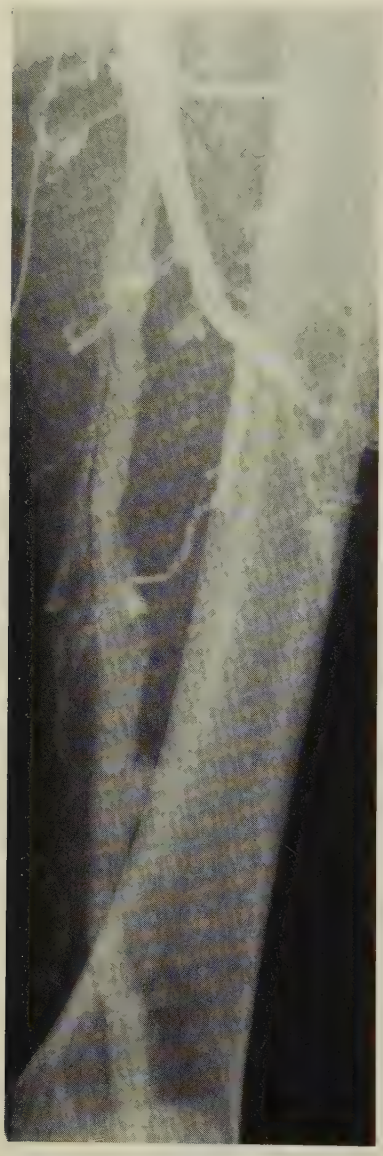
Venous pressure determination:

S.V.P.: 132, W.V.P. I: 29, W.V.P. II: 43, W.V.P. III: 50.

XVIII. *Ascending phlebogram.* Patient of group III. Local changes in the deep veins of the leg; obstruction, collaterals following a tortuous course; absence of incompetent perforators; valve perceptible in the popliteal vein.

Venous pressure determination:

S.V.P.: 129, W.V.P. I: 11, W.V.P. II: 34, W.V.P. III: 34.



XIX

XX

XIX. *Descending phlebogram.* Patient of group V. Retrograde filling of the femoral vein in which valves are not perceptible: sequelae following recanalization.

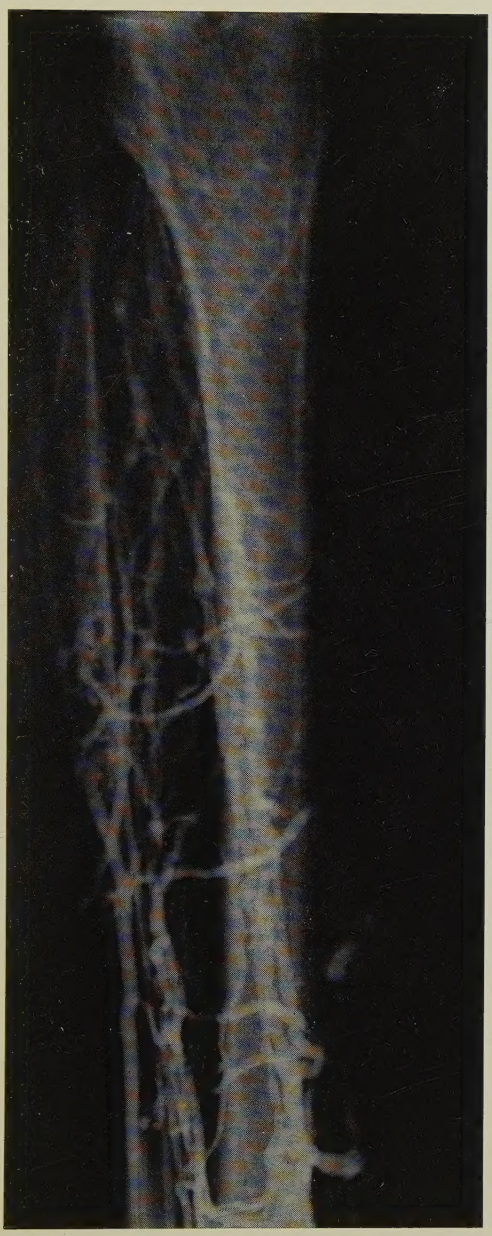
The deep femoral vein also shows partial retrograde filling, though valves are present distally in this vein.

Venous pressure determination: the pressure did not fall during walking.

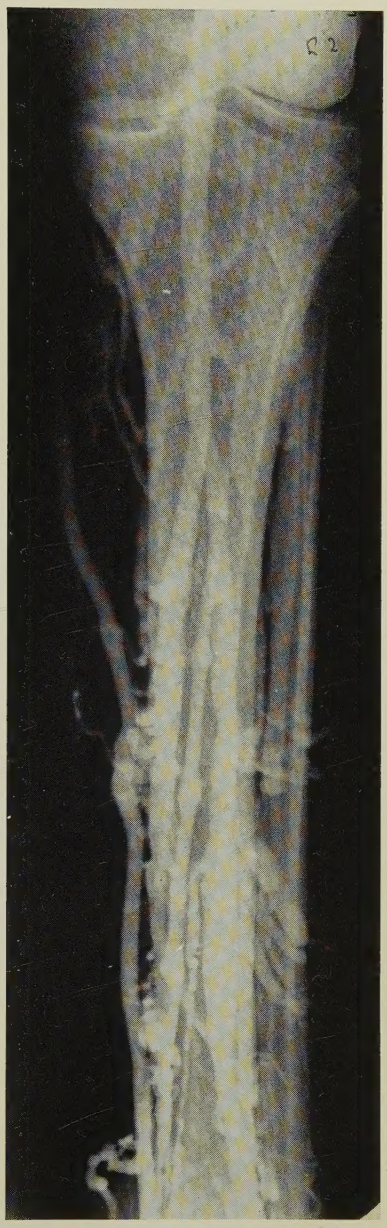
XX. *Ascending phlebogram.* Patient of group II. Normal deep system of the leg, valves being present; two incompetent perforators on the medial side.

Venous pressure determination:

S.V.P.: 126, W.V.P. I: 20, W.V.P. II: 41, W.V.P. III: 57.



XXI



XXII

XXI. *Ascending phlebogram.* Patient of group VI. Post-thrombotic deep system of the leg, characterized by partial obstruction, collaterals following an abnormal course and absence of valves; incompetent perforator on the medial side.

Venous pressure determination:

S.V.P.: 142, W.V.P. I: 13, W.V.P. II: 0, W.V.P. III: 21.

XXII. *Ascending phlebogram.* Patient of group II. Normal deep system of the leg, presence of valves; two incompetent perforators on the medial side.

Venous pressure determination:

S.V.P.: 128, W.V.P. I: 30, W.V.P. II: 30, W.V.P. III: 60.

XXIII

Apparatus used in venous pressure determination. The graduated tube is secured to a stand along which it can be slid up and down.

On the underside is a three-way cock by which the tube is connected with a polythene catheter and which also serves to fill the tube with physiological saline solution from a 30 ml. syringe.

The polythene catheter is inserted directly into the vein.